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The Labiobuccal Retainer

Paul D. Lewis, D.M.D.*

Seattle, Washington

In the past several years many phases of orthodontics have received increased attention, such as appliance technics, cephalometric diagnosis, and treatment planning, to mention but a few. This certainly is as it should be — it is advancement, it is progress — and few, if any, would have it otherwise. The study of retention, however, has hardly kept pace. Emphasis has not been placed upon the problems of retention, and maybe that is why it has been rather aptly called the "step-child" of orthodontics.

A study of the problems of retention has long been of special interest to the writer. Foremost among retention problems are how to maintain the teeth in function and in their new positions, and how to prevent relapses. How to do this successfully is what I would like to discuss with you, and I hope you can benefit from some of my experiences. Do we always get perfect results? No, naturally not, but the percentage of stable end results has increased markedly.

Retention is a subject that can generally be discussed in most orthodontic circles because, regardless of whether one is a one hundred per center or occasionally extracts bicuspids, retention of one's cases is a problem to most of us. It is one of the so-called "facts of life" that eventually faces us in the majority of our cases.

Someone once said that orthodontics is a science but retention is an art. That the science of orthodontics can be taught is quite self-evident, but I have felt for a long time that the art of retention cannot be taught easily but is something that has to be tried again and again by most men before it is understood and mastered. It is a constant battle — making teeth remain in new positions and function there after bands and appliances are removed.

Quite recently a good orthodontic friend of mine asked me, "Why is it that my cases, which look so good to me as they become ready for retention, too often look so poor in retention when it should be just the reverse?" Years ago I heard an old orthodontic saying that went like this, "I'll treat the case, you retain it, and I'll give you half the fee." Many of you, I am sure, can recall having heard this and, even though it is a little unrealistic, it still expresses well the apprehension that men have had and continue to have for this very important but often neglected phase of our work.

There is more than one school of thought regarding the subject of retention. A poll taken at a recent meeting showed the older members as favoring formal retention for their cases while the younger men present were less interested in retaining cases after treatment. Was this because the older men, who had practiced more years, had witnessed too many of their own well-treated cases relapse from little understood or careless retention on their part?

Let us discuss for a few minutes what I feel are fallacious lines of reasoning with regard to this subject. The first

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one is this, "If malocclusions are ideally corrected, the forces of the inclined planes will be sufficient to balance the denture, and formal retention will not be necessary."

I do not believe that many of the younger men, and surely none of the older, will accept this one-time rather popular theory. To anyone inclined toward this line of thinking, one has only to remember that osteoid-type bone is a very poor substitute for mature bone in holding teeth in their proper places while withstanding the muscular stresses and forces of occlusion that are always present even during retention. Some form of support or splint is necessary in most cases after band removal to support the teeth until bone tissue is reorganized.

The second line of reasoning is this, and again I am addressing myself principally to the younger men. Why retain, is the attitude of some men whose rather logical argument is, "If the teeth are going to relapse sooner or later why not have them do it sooner? In short, let's get on with the relapse and see how bad it is going to be." That actually was the attitude of a group of men I talked with not too long ago. I think in general we would agree that this is faulty reasoning. Why go to all the trouble and expense of doing the work just to let the teeth relapse? Too many successfully treated and retained cases testify to the benefits of well planned and carried out retention to accept such a faulty argument.

For many years there has been a need for something better than what we have had for maxillary retention in certain types of cases. I refer more specifically to the treatment of Class II cases in which a considerable amount of intermaxillary elastic traction has been necessary. Retention is most generally a problem with the child who has had a Class II malocclusion, a hypotonic upper lip, and who, because of habit or allergy, cannot or will not use his lips correctly. In such cases Class I molar relationship, attained through the use of rubber elastics and headgear wear, is often impossible to hold or maintain during retention. During retention, the maxillary teeth too often move forward again following the removal of the distal restraint, and are followed by the mandibular teeth which attempt to remain in Class I relationship. The lower teeth fit better in a forward position, and the patient may also realize he looks better with his lower jaw forward; thus a convenience bite is started, a dual bite is created. Many times in these once protrusive cases, the best of ordinary retainers are not capable of holding the maxilla in Class I occlusion.

At the 1952 Tweed meeting in Chicago, during a symposium on retention, I described the use of the .045 archwire, with an auxiliary spring and headgear, showing its restraining effect on the teeth of the maxillary arch. This was termed active retention. Though not perfect, this approach proved to be a step in the right direction because it employed the use of a distally directed force on the maxillary teeth as the initial step of retention after band removal. The effect of this archwire on the teeth anterior to the molars was not ideal in all cases because it was sometimes difficult to close open contacts in the bicuspid and cuspid region, even in conjunction with a headgear. Neither did the combination of wearing a maxillary retainer by day and an .045 archwire with headgear by night seem to be the answer in some of these once protrusive Class II cases. The problem was: how to get these stubborn retention cases out of one's practice.

In an effort to prevent the creation of a dual bite from developing and to assist in maintaining the Class I buccal

relationship established during treatment, I would like to discuss with you a method or approach to retention I have been using for quite some time. When basic treatment of a case has been completed, that is, when the case appears to be practically finished, an inspection tour is started before any bands are removed to determine if the case is ready for retention. The following points are checked:

1. Has the overbite been adequately reduced?
2. How about the mesiodistal relationship of the teeth in the buccal segments? Are these teeth really in Class I occlusion?
3. Have the maxillary cuspids been carried fully back to the bicuspids so that they are in their correct relationship to the lower cuspids?
4. Examine the upper six year molars — have they been rotated sufficiently, or are the mesiobuccal cusps still rotated to the lingual?
5. Do bicuspids, cuspids, or incisors need more rotation?
6. If our case has been one in which teeth had to be removed, it is wise to check to see if the roots adjacent to the extraction areas are parallel.
7. Check also to see if the roots of the upper centrals and laterals have been torqued lingually an adequate amount.
8. Is there a dual bite?

If all these points check out favorably, then retention is started. It takes only a few minutes to make this inspection tour and you may be sure it pays to do it before many bands are removed because these same steps are difficult and, in some instances, impossible to do with retainers after the bands have been removed.

It will probably be conceded that Class II extraction cases, as a rule, present more problems, both in treatment and retention, than non-extraction cases. Therefore, let us discuss some of the preliminary steps in the retention of a Class II case in which it was necessary to remove four first bicuspids.

Generally, the lower second bicuspid bands are the first bands to be removed. The bands on the six anterior teeth are lightly stripped with lightning strips to reduce band thickness at the contact points. Small coil spring sections (¼" in length) are placed on the archwire mesial to the second molars and are tied back. Light Class II elastics are worn to move the first and second molars forward, closing the second bicuspid band spaces. Next, the first molar bands are removed and again the coil spring sections are tied back to the second molars, and light Class II elastics are worn closing the first molar band spaces. When the cuspid bands are removed at the next appointment, Class II elastics are discontinued and the coil spring sections removed from the archwire.

The archwire at this point is usually retied for at least one week before the lower incisor bands are removed. The Class III elastic hooks may be bent distally until they rest lightly on the lower cuspids if expanded intercanine measurements prove this to be necessary. Just a very little pressure is needed at this time to narrow these two teeth toward the original intercanine width.

The four lower incisor bands are finally removed and only slight spaces remain between these four teeth. The lower archwire is checked for arch form and then is ligated lightly to the second molars. The archwire is bent away from the cuspids to prevent moving these teeth too far lingually, but rests lightly against the four incisors. The spaces between the anterior teeth close very quickly and the contacts between the cuspids and second bicuspids are maintained by this slight

pressure from the archwire. We are in no hurry at this time to make a lower retainer. The archwire remains on from one to three weeks before a lower impression is taken and sometimes another week before the retainer is placed. This is as good a way as I know to keep extraction spaces from opening, help contacts to close, and maintain lower cuspids at their proper intercanine widths.

Let us recap for a moment. When Class I occlusion has been attained and our case appears ready for retention, a thorough inspection is made. Next, the lower bands are removed in pairs so that band space can be gradually closed by light elastics worn between appointments. When band removal is followed this way, correct arch width can be regained in the molar, bicuspid and cuspid areas. This procedure also allows the mandibular buccal teeth to return to a more favorable buccolingual inclination. Lower arch form is improved, contacts are closed, and intercanine width corrected before the impression is taken for a lower Hawley retainer. In short, over expansion, open contacts, band spaces, and the too vertical axial positioning of the buccal teeth are not maintained and perpetuated by placing a lower retainer too soon.

During the time lower band removal is under way the headgear is being worn against the maxillary teeth fourteen hours per day. This is very important and cannot be overemphasized. The second bicuspids are the first upper bands to be removed and follow very shortly the removal of the lower bicuspids. As in the lower arch, the upper first molar bands are removed next, in the event the second molars carry the anchor bands. At a later appointment the cuspid bands are removed and finger springs are soldered to the archwire to tuck the cuspids in and back in contact with the second bicuspids. When the upper anteriors have been carried back as closely as possible to the retained lowers by the action of the headgear, the four upper anterior bands are removed and upper and lower impressions are taken for the purpose of making a new type of maxillary retainer which I have called the labiobuccal retainer.

The technic for the construction of this new type of retainer is as follows: Upper and lower alginate impressions are taken, together with a wax bite in centric occlusion. All loose and open contacts in the maxillary arch are recorded in writing. When the models are poured and trimmed, Fig. 1 above, a typical positioner set-up is made on the upper model only. Generally, a minimum number of teeth have to be changed on the maxillary set-up due to the care with which band removal and space closure has been followed in both upper and lower arches. (Fig. 1 center).

Wire clasps are bent to lay across the labial of each central and to engage their distal surfaces above the contact points. Similar clasps engage the labial and distal of the laterals. (Fig. 1 bottom) The clasps gripping the distal of these four anterior teeth afford retention for the appliance when it is fitted and worn on the maxillary teeth.

The retainer is constructed on the labial and buccal surfaces of the maxillary model, using fast-setting acrylic. Two small squares of plexiglass are imbedded in the acrylic as it is setting on the labial surface, just distal to the centrals. Holes are bored in these plexiglass blocks to receive the headgear hooks later. After setting one-half hour the retainer may be removed from the model, trimmed and is then ready for a try-in. (Fig. 2)

In December, 1954, a positioner set-up was made for a retention patient who had once been very protrusive. It was a non-extraction case, and the

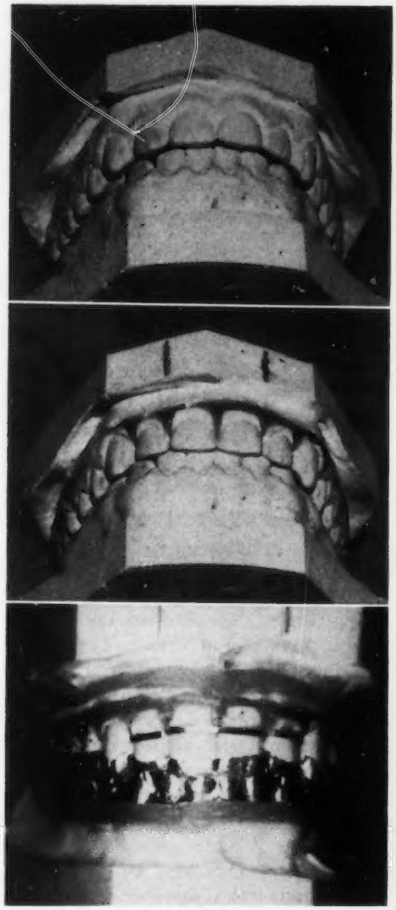

Fig. 1 Above, Casts after band removal. Center, resetting of some maxillary teeth, reducing overjet. Black lines indicate approximate position of plexiglass hooks. Bottom, models waxed together with wire clasps distal to upper laterals and across centrals. Tinfoil is cemented to prevent acrylic from seeping between teeth.

Class I molar relationship in retention was slipping. Due to the unstable occlusion of this case, an attempt was made to fabricate an appliance of acrylic on the positioner set-up, covering the labial and buccal surfaces of the maxillary teeth. It was placed in the patient's mouth and she was instructed to place it in her mouth and push on it with her fingers for one-half hour before retiring, and, of course, to sleep with it in her mouth as well. Little or nothing was expected of this appliance when it was placed. It was thought of as a one hundred to one shot! The patient was seen at infrequent intervals and, even though the molar relationship improved and became quite stable through wearing this crudely made appliance, little significance was attached to it at first. Months would go by between visits, and yet, this once protrusive non-extraction case that had developed a dual bite improved. It became stable.

Finally, I began to wonder if this

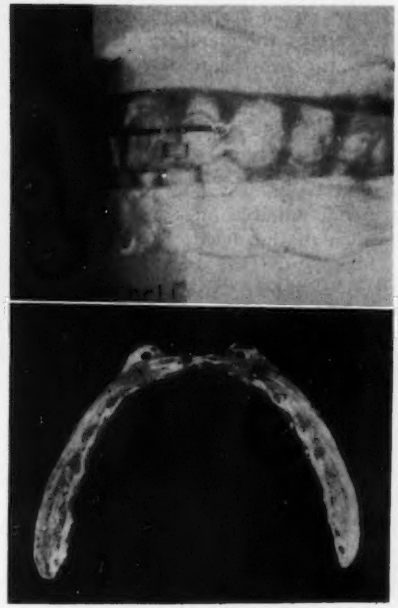

Fig. 2 Finished retainer trimmed so it will not touch mandibular teeth. Correct position of plexiglass hooks should be noted. Below, another view showing plexiglass hooks and lingual position of the wires around centrals and laterals.

rather simple device might not be just as effective on other cases as well. Gradually and cautiously more were tried on different types of cases, extraction and non-extraction, which had definitely slipped during and after retention. Some had slipped a little, others more. All of them were helped by the use of this new type of retainer. Then it was used on cases immediately out of treatment with equally good results.

At first, finger pressure alone was depended upon as the source of power to be applied to this new retainer. It was definitely felt that some sort of power or pressure was necessary to make the appliance really effective. It was also felt that if in some way the headgear could be applied to this retainer, it could become far more effective in its purpose of retaining and restraining the maxillary teeth in these once protrusive cases. Several different ways were tried in attaching the headgear hooks; finally, it was found that two small pieces of plexiglass, imbedded in the acrylic as it was curing, could be shaped later so they would provide suitable hooks from which to attach the headgear. (Fig. 3)

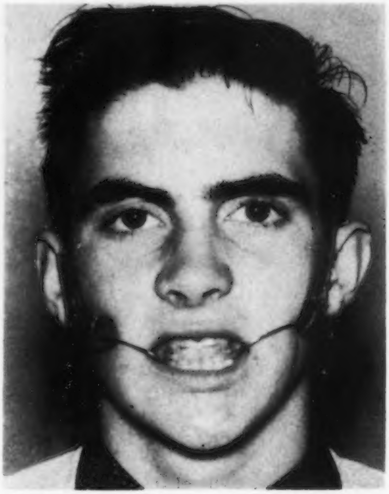

Fig. 3 A retainer in the mouth with headgear attached.

Each time the labiobuccal retainer has been used, molar, bicuspid and cuspid relationships have been maintained or improved to the extent that the teeth have rapidly assumed a finished look about them. Overjet has improved in all cases in which the bands had just been removed; the degree of overjet achieved in active treatment has been maintained by the application of the labiobuccal retainer.

A headgear has been worn on all but the first few cases on which this retainer has been used. Finger pressure was used on the first cases with good success, but the headgear has proven to be much more effective. When the occlusion settles in good Class I molar relationship and there appears to be no tendency to change, the headgear time is gradually decreased to every other night, then twice a week, etc., then discontinued. Naturally, when treating a Class II case, or any case in which protruding teeth have been a problem, more precaution is exercised and greater length of time is necessary before the headgear may be discontinued.

At the time the labiobuccal retainer is being constructed for the upper, a conventional Hawley type retainer is made and worn on the lower arch. When retention of the lower arch has been approached as has been described, the lower teeth need the lingual support of a Hawley type retainer. It may be a wise precaution after wearing this mandibular Hawley type retainer for six months to change to a cuspid to cuspid fixed or soldered retainer. This procedure is routine in our practice.

It has been our experience that patients do not object to wearing this new type retainer and there is little objection to the headgear either. The patients especially appreciate the free-

dom and ability to talk with this appliance in their mouths, even while wearing the headgear. Another feature worth mentioning is that of cleanliness. Everyone occasionally has had the experience of removing Hawley retainers and, with a sickening feeling, noting the damage to hard and soft tissues in the mouths of some careless patients. The labiobuccal retainer minimizes much of the chance of this damage in the maxillary arch.

The maxillary Hawley type retainer, situated as it is on the inside of the upper arch, many times retains and maintains overexpansion, loose contacts, and spaces, when it is used immediately after band removal unless carefully watched and constantly modified. On the other hand the upper arch is far better when the labiobuccal retainer is used because the restraining action of the retainer, plus the active force of the headgear, is directed from the buccal and labial segments of the maxillary arch, instead of from the lingual, thus inducing tight contacts, better overbite and overjet, and improved occlusion. When one is dealing with an allergic patient or one with a short upper lip and flabby musculature, the labiobuccal retainer ideally supplies the restraining pressure which is so often lacking in these cases.

This method of retention is consistent with accepted descriptions of the forces of occlusion. Moore has described these forces as follows: "The buccinator and the superior constrictor are a continuous band of muscle surrounding the entire denture, being attached posteriorly to the spinal column. These muscles can thus be considered as an elastic force surrounding the entire denture and being responsible for molding the maxillary denture against the lower contained mandibular arch.

In order to summarize the functional forces of occlusion, it may be stated that generally speaking these forces create a buccal and labial force upon the maxillary denture and a lingual force upon the mandibular denture. It should be emphasized that the mandibular arch form is determined primarily by the lingual forces created by function. The contact of the mandibular teeth with one another produce a contained arch around which the buccinator muscle and the incline plane relationship of the teeth mold the maxillary denture."

This new type of maxillary retention has been used successfully in well over one hundred cases in our office. In some instances it has been the only maxillary retention used. After the labiobuccal retainer has been worn for awhile, after the overjet has been reduced, and the contacts closed, we have found it beneficial in many cases to use a maxillary Hawley type retainer during the daytime to hold the four incisors together and to assist in maintaining the overbite.

What I have attempted to tell you is that if retention is started on the lower arch first, if all the band spaces in the lower arch are closed and held closed as described above, then it is possible to get the maximum from the labiobuccal retainer. The architecture of the lower arch should and can be very close to what is meant for that individual before a lower retainer is made. It is then that the teeth in the maxilla can be moved back and draped around the retained lower most effectively for better retention.

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Cephalometrics In Clinical Practice

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To those of you who are not fully employing cephalometric principles in your orthodontic practices, I ask these questions: "Do you really want to know what you are doing to your patients, or are you afraid to find out? Do you suspect that, if you did know, you might sometimes be unhappy? If you did not like what you found, would you do something about it?" If the answer to these questions is no, then you don't need a cephalometer. If the answer is yes, then careful and intelligent use of cephalometric principles can be the means of greatly enhancing your usefulness to those you serve. Even though some of these principles are being used by a large percentage of the orthodontists today, this usage is generally superficial and falls far short of the potential benefits that are available.

The greatest value of cephalometrics is in the field of comparative studies; such comparisons divulge and demonstrate changes that have occurred and strongly indicate the responses to the treatment therapy that has been employed. Cephalograms demonstrate not only the effectiveness of treatment, but also what is equally, or even more important, its shortcomings. Properly viewed, they give strong evidence of the anchorage principles employed and the degree of its effectiveness. I refer not only to the bodily movement of teeth, but also to their inclinations, which indicate whether movement has occurred bodily, root first or crown first. A discerning and experienced eye can also see the story of tissue responses, bony changes and, sometimes, changes of muscle function.

This knowledge is not gleaned from a few simple measurements on an original cephalometric tracing. It becomes apparent only from carefully superposed serial tracings and from comparison of important serial measurements. Those of you who are not faithfully and routinely making and studying progress or "follow-up" cephalograms, taken during and after both treatment and retention, are, in my opinion, missing the principal benefits made available by the cephalometer. A knowledge of what we have done and, particularly, what we have not done, moulds and crystallizes our treatment philosophy and conditions it for better service for those who come to us for treatment.

Much credit should be given to Broadbent and to those other men who participated with him in doing the groundwork which led to the creation of the cephalometer. Acknowledgement must be given also to those who developed methods to make cephalometrics useful to clinical orthodontists. High on the list of these is Downs who first gave us a practical method of using cephalometrics in clinical practice. Basic ideas developed by him are still the foundation for most of the later developments that have evolved.

Four years ago we suggested a series of measurements, which, at that time, we felt were a vital minimum for treatment diagnosis and for a determination of the results achieved during treatment.[18] Some of these measurements were ideas of, and had been originally presented by, Downs, Riedel, Thomp-

Read at the Charles H. Tweed Foundation for Orthodontic Research, Tucson, Arizona, October, 1956.

son, Wylie and others. To these we made additions. Time and the clinical experience of many practitioners have now tested them. These testings indicate the need for some additions and modifications of the original measurements. Further time and usage will undoubtedly point out others. The modifications and additions now proposed have evolved principally as the result of studying comparative tracings made during and after treatment.

To try to justify all of the measurements that we have proposed in the past is clearly contra-indicated in this paper. I believe, however, we should try to encourage the use of those that relate to the mandible, for they have not all been widely used and do involve what are probably the most vital and important questions before the profession today. These questions are: *Can we stimulate or retard the growth of the mandible by orthodontic means* and, if so, *how can it best be accomplished?*

There has always been a marked difference of opinion among orthodontists as to what constitutes correct and effective therapy for the mandible. These opinions vary from simply "jumping the bite" to various appliance procedures aimed at changing its size, shape and location. To those of you who have a desire to know what effect your treatment is having upon the mandible, I sincerely suggest that, if you follow the technic we have outlined, you will obtain much valuable information.

This procedure necessitates adequate pictures, not only of the body of the mandible, but of the ramus, neck and condyle as well. The following thoughts may be helpful to those of you who take cephalograms in your offices.

Because the condyle lies partially hidden behind the zygomatic process and is sometimes partially covered by the ear-posts of the head holder, it is helpful to give this area additional radiation by filtering out all other areas while the exposure is being made. This will "burn in" or more fully expose the condylar area (Fig. 1). If necessary, the soft tissue profile can be filtered in by the reverse process.

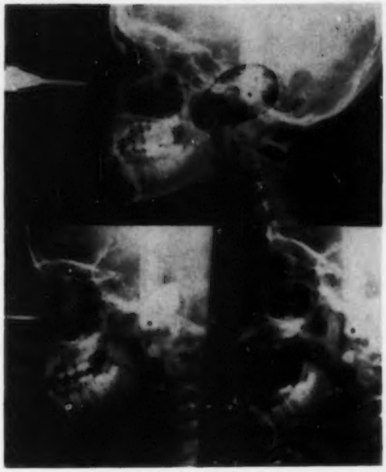


Fig. 1 Above, method of filtering the rays to more fully expose the condylar area. Below, one half of the film is used to record the condyle with the mouth wide open. The other half is used to record the rest position and the soft tissue.

A more accurate and satisfactory method of recording the condyle is to take an additional picture of the mandible with the mouth wide open so that the condyle is moved forward and downward and free of the zygoma (Fig. 1). A template of it can then be made and used for other tracings of the case. The other half of the same film may be used to demonstrate the rest position, to show the soft tissue outline, or for such other purposes as may be desired (Fig. 1).

With pictures of the complete mandible (Fig. 2), its size and shape can be observed and measured. It can be located anteroposteriorly by projecting it onto the line SN and locating this

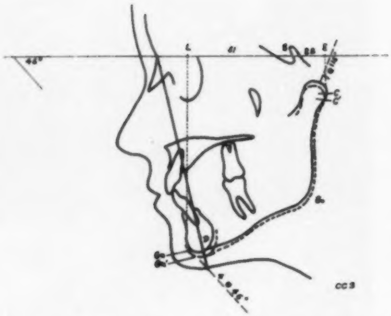


Fig. 2 A plea is made to record all of the mandible including the condylar area. Important growth changes occur in this area during the orthodontic age span. The direction and distance of closure from the rest to the closed position can be recorded and should be of interest to orthodontists.

projection with reference to the point S. The distance SE is of special interest (Wylie) because it infers condyle to hinge-axis relationship anteroposteriorly. The mandible's inclination can be determined by recording the angle GoGn-SN, a principle used by Downs.

If you are sufficiently interested in function and in the thoughts of Thompson and others regarding it, and I think you should be, you can use a cephalogram of the rest position to record the direction and the distance of the movement of the condyle and of the chin, from rest position to closure (Fig. 2).

I must confess that although we now have hundreds of records of the direction of the mandible from rest to the closed position, and have a large sample of the results of treatment on these positions and motions, we do not know as yet how to make specific use of this information advantageously in our orthodontic problems. We do know that it tells part of the story of function and that function is fundamental to orthodontic knowledge. We have found, as others have, that in cases of malocclusion the rest position is generally different from the rest position of normal occlusions. We have ample evidence that, when malocclusions are successfully treated, the rest positions generally change to one more nearly or actually resembling that of a normal occlusion. (Fig. 3).

For those of you who are busy in clinical practice and are looking to the universities and to others for the development of new ideas and guidance, I do not feel justified in pleading for the use of these recordings of movement. I do sincerely hope that your interest in advancing orthodontic knowledge will stimulate you to gather further information in this field. These measurements and comparisons do give us a peep through a small window into that complex and nearly dark, but highly important, cavern of mystery, function.

To those who are interested in knowing whether or not mandibular growth is being produced by orthodontic means, I make a strong plea for recording the

Fig. 3 A. The closed and rest position before treatment. Fig. 3 B. Closed and rest position after treatment. A comparison shows the changed direction and distance of the closure of a treated case. Note the more normal closure after treatment.

entire mandible, including its principle growth centers, the ramus, the neck and the condyle. I also suggest that both before and after treatment tracings of it be carefully related to a check point so that changes in its location may be measured and evaluated and thus be distinguished from growth. We have used point S in this manner.

Let us now consider some of these new measurements and assessment principles. The first and most important of these was described to us by Holdaway. I believe it to be extremely important and I wish to give him full credit for bringing it to my attention. We have used it for some time and have adopted it as a part of our routine analysis.

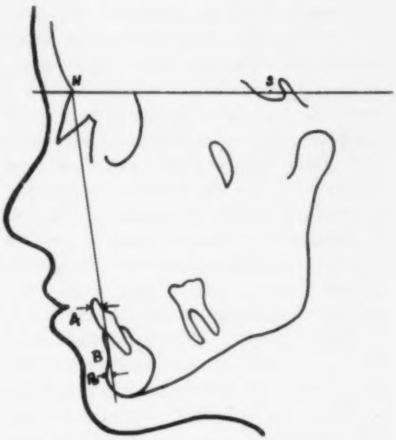


Fig. 4 The measurements pogonion to the line NB and lower incisor to the line NB. These measurements are related and should be considered in treatment and diagnosis (Holdaway).

I am sure it has been obvious to all of you that the chin contributes generously to the facial outline, especially in profile. It practically establishes the character of the lower face. We have carefully considered the anteroposterior relationships of the teeth and the part they play in determining facial contour. We have talked about point A and point B but have said little about an evaluation of the chin point. The anteroposterior location of the chin can be expressed as point pogonion (Po).

Certainly the degree of prominence of the chin should contribute tremendously to a determination of the placement of the teeth. Therefore, let us measure from pogonion (Po) at right angles to the line NB and record this measurement as is shown in Figure 4. This distance will vary so widely among individuals that a mean measurement for it would have little diagnostic value. The relationship of the measurement, pogonion to the line NB, to the measurement, labial surface of the lower incisor to NB, is the important factor to be considered. The difference between these two measurements will vary widely among normal individuals because the chin point varies considerably, according to type, in all individuals. It is now too early to make definite predictions as to what the relationship of these measurements should be. At the present time Holdaway would like to see the distances, pogonion to the line NB and lower incisor to the line NB, equal. He believes that, if the overlying soft tissues are of average thickness and arrangement, acceptable results can be achieved when these measurements vary within a range of two millimeters. He regards a three millimeter variance as being less desirable but tolerable. He states that, when the difference between them is four millimeters or more, extraction of teeth or other remedial measures are generally necessary to bring the differences within acceptable limits. I have seen ample proof that the ratio between these two measurements can be greatly influenced by orthodontic therapy and, in most instances, can be brought within acceptable limits.

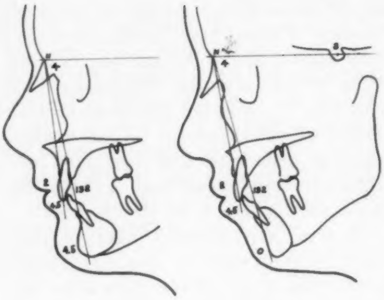
We have now had enough experience with the use of this measurement,

pogonion to NB, to know that the location of pogonion as related to the other structures of the face has a direct bearing on the manner in which, and I quote Holdaway: "the neck and facial muscles drape over the chin and neck and thus affect both esthetics and function." The location of pogonion is certainly one of the important factors in establishing facial contour and it must be carefully considered along with other factors when estimating the proper placement of the teeth.

Both tracings shown in Figure 5 have an ANB angle of four degrees. The relationship of the upper teeth and the lower teeth to their respective lines NA and NB are identical. The two cases differ in the measurement pogonion to the line NB. It is obvious that this difference indicated an individual placement of the teeth for each case and that the same treatment for both cases is contraindicated. It is equally clear that the measurement Po to NB has a direct bearing on this difference.

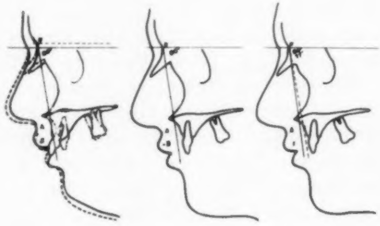
From our early experience with cephalometric tracing we have known that the alveolar process about the teeth moves markedly as the teeth are moved and that it continues to move and to adjust itself during and after the retention period. These changes involve point A (Fig. 6A). For that reason we have suggested that the angle SNA and the line NA be copied from the first tracing to all serial tracings (Fig. 6B) to accomplish correct positioning of serial tracings for comparison and to provide identical lines from which to measure and assess the location of the upper central incisor and the first molar. These measurements are comparable only if they are made to identical lines.

We now suggest that in addition to carrying forward the old angle SNA and the line NA from the first tracing to all other serial tracings, we also draw the line NA on the new tracing in the usual way, using the new point A, which in many instances will have moved as the teeth have moved (Fig. 6C). If movement has occurred to point A, it will create a different SNA angle



A B

Fig. 5 Two cases that have identical measurements, except that in case (A) the pogonion to the line NB measurement is 4.5 mm. In case (B) it is 0 mm. Obviously these two cases require different tooth replacement and the measurements Po to NB and I to NB are vital to the determination of this difference.



A B C

Fig. 6 (A) Showing the change in point A during treatment. (B) After treatment with the angle SNA and the line NA copied from the first tracing onto the second one. This is for the purpose of superimposing these tracings on the maxillae and to determine the movement of the maxillary teeth in the maxillae. (C) After treatment tracing, with both the original line NA (solid) copied from the first tracing and the new line NB (dashed), which evaluates the changed location of the maxillary apical base.

and thus relocate the apical base of the maxilla.

Consider now the mandible and the mandibular teeth. Point B moves within the mandible as the lower incisors are moved, but generally not to the same extent as does point A when the upper teeth are moved. As point B moves, the line NB moves correspondingly and the measurement, lower incisor to the line NB, is thereby influenced even though the incisor has not moved. The angle SNB has also changed as a result of the changed position of point B, within the mandible, even though the position of the mandible may have remained constant.

For a long time we have searched for a more stable and revealing point on the mandible from which to measure and express movement of teeth and the changed positions of the mandible. The location of this point should be as devoid of growth changes and be as free of the influences of the movement of teeth and other environmental influences as is possible. Pogonion is not good, for it is the site of secondary growth changes, particularly in the male. We had hoped that the junction of the lower border of the mandible with a cross section of the symphysis might be useful, but tracing experience soon ruled it out because the junction of the lower border of the mandible with the symphysis is a gradual transition and is often vague. We have also tested muscle attachment areas and typical depressions without finding one that offered much promise. For some time we have used a new point which we believe is logical and useful as a diagnostic landmark.

The majority of the profession accepts point S as being an acceptable estimate of the center of sella turcica and believe it to be a reliable and useful landmark for measurement. If the possibility of determining the exact center of this irregular figure is questioned, we can logically answer that it can be estimated within a fraction of a millimeter and that this degree of accuracy is sufficient for our purpose, providing this estimate is carried over to subsequent tracings by copying the point from the first tracing when they are correctly superposed.

By a method that is similar to that used to establish point S, we can establish a point on the mandible to serve an equivalent purpose. We will consider only the cross section of the body of the symphysis. We will ignore the alveolar process for it is influenced by the positions of the teeth and is changeable. Either visually, or with instruments, establish a point at the center of the mass of this cross-section. We will call this point D, Fig. 7. Like point S in the cranium, it is well surrounded by sturdy bone; it is protected from outside influences and is well isolated from the areas where movement of the teeth and normal growth changes occur. Deviation from the exact center of the symphysis is not serious. The point is to be used principally as a reference point and is to be transferred to subsequent tracings by copying it directly from the first. It can be copied onto subsequent tracings as accurately as you can superpose the tracings of one mandible over another. This is not easy, for over a period of time practically all parts of the mandible change in both size and shape.

We believe that the most accuracy can be achieved by the following method. First, let us freely admit that points Go and Gn are difficult to locate and therefore the line GoGn is not always ideally placed. We can minimize the undesirability of this error by copying the line GoGn from the first to subsequent tracings and, for use as a reference line, this nullifies the possible error. To copy it accurately we must superimpose the tracings by using all of the evidence that can be found any-

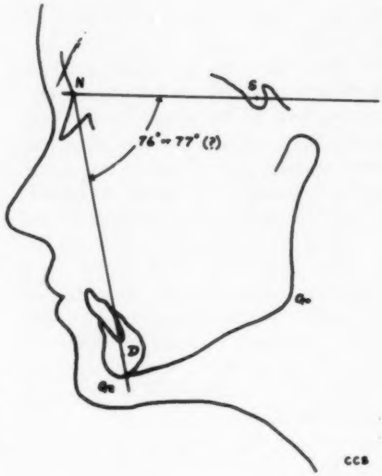
Fig. 7 Point D is located at the center of the cross section of the body of the symphysis. We suggest it to represent the anteroposterior location of the body of the mandible and to evaluate changed positions of it. Illustrated also is a method of superimposing tracings of mandibles.

where on the mandibles.

Especially to be considered is the cross section of the symphysis, particularly its lower and posterior borders, with special emphasis on those portions just above and below the attachment of the geniohyoideus and genioglossus muscles (Fig. 7). These areas show a minimum amount of change. Having established this superpositioning and seeing that the lower borders of the mandibles as well as the ascending rami are parallel and the direction of the growth of the condylar areas is in the right direction, copy the line GoGn and the point D from the first to the subsequent tracing. The line GoGn and point D will serve the same purposes for the moving mandible, as does the line SN and the point N for the rest of the skull. When the mandible moves, line GoGn and point D move with it.

We now measure the angle SND (Fig. 8-above) as an assessment of the position of the mandible in its anteroposterior relationship to the rest of the skull. Let point A and point B continue to express the apical bases of the denture and let the angles SNA and SNB demonstrate the location of these apical bases to the skull and to each other. Angle SND more accurately expresses the location of the mandible, as a whole, to the skull.

It has been our experience, and I think you will find it true, that an assessment of the changing positions of the mandible arrived at by using the angle SND will record changes more



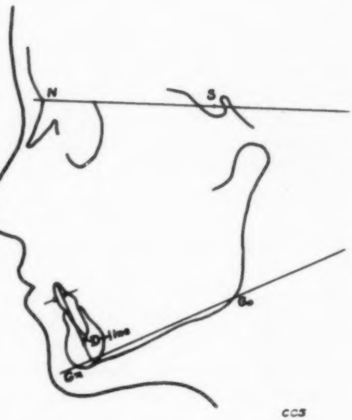


Fig. 8 Above. Angle SND is suggested to express and evaluate the anteroposterior location of the anterior portion of the mandible in relation to the head as a whole. Below. Line D is erected through point D and perpendicular to the line GoGn. It is used to locate the position of the lower central incisor.

accurately than when using the angles SNB or SNPo.

Point D can also be used to determine changes in the position of the mandibular teeth within the mandible. To do so, erect a line through D perpendicular to the line GoGn to a position even with the incisal edge of the lower incisor. (Fig. 8-below). We will call it the D line. It will generally pass through the lower central incisor but the varied relationship of this tooth to this D line will surprise you. It will convince you not only of how teeth in malocclusion vary in their relationships to the mandible, but also how teeth in normal occlusion in different individuals vary in this regard.

To locate the incisor to this line, measure at right angles from the line to the most anterior point on the crown. Also measure the angle formed by the long axis of the tooth to the D line. Because the upper end of the line was drawn even with the upper extremity of the incisor in the original tracing, the line, when copied to subsequent tracings, can also be used to determine depression or elongation of the incisor teeth.

The D line is transferred to serial tracings directly from the first one by superpositioning, as is also the line GoGn and the point D. Because the line travels with the mandible in exactly the same manner as do the incisors, it is useful in locating these teeth in the mandible and in determining changes of their positions in serial tracings. For treatment planning, we still prefer to evaluate the positions of the lower incisors to a facial plane.

A more graphic method of determining changed positions of teeth that is both accurate and revealing will now be described. Its accuracy is directly dependent upon our ability to superpose serial tracings.

When we compare serial tracings, we are accustomed to superimposing them one on the other for the purpose. Cases are usually reported at meetings and in the literature by using superpositioned tracings which are distinguished one from the other by the use of solid and broken lines. These drawings are often complicated and confusing. We offer the following method as being simple, clear and easily understood.

Because it is important to the method of superpositioning, let me first say that in our office we use colors for serial tracings. They help to select specific serial tracings and to distinguish one from the other when comparing them. After considerable experimentation and thought, the following colors have been selected and their use is recommended. For the original tracing, black is used for all lines and measurement figures. After treatment tracings are done in red, intermediate tracings in blue, retention tracings in green and subsequent tracing in terracotta. These colors have been chosen for contrast, sensitivity to color film for ease in slide making, availability of quality pencils, etc. To identify their origin, all lines and figures are copied from one tracing to subsequent ones in the color in which they originate. Due to the unavailability of colors we will use solid and broken lines in this printed article to represent different colors and, in that way, identify different tracings.

When comparing an after treatment tracing with a before treatment tracing to determine changes that have occurred to the upper incisor, superimpose the serial tracings under discussion as follows; place the second or after treatment tracing, on the first, with the lines SN superimposed and registered at N. With a black pencil copy the line NA of the first tracing onto the second tracing. Now slide the second tracing up or down along these black lines until, by the greatest amount of evidence in the region of the maxillae,

the drawings of the maxillae are superimposed (Fig. 9-above).

Now, represent the position of the incisor of the first tracing onto the second tracing by drawing a dashed line from the tip of the incisal edge to the tip of the root of the upper incisor tooth of the first tracing (Fig. 9-above). Place a small but definite dot at each end of this line to clearly determine its ends. We call this line the upper incisor line.

View the second tracing alone (Fig. 9-below). The dashed line just described is a graph of the upper incisor as it occurred on the before treatment tracing. It demonstrates its original position anteroposteriorly and vertically and shows its original inclination. By comparing the line with the drawing of the incisor in its new position after treatment, you can determine how far the root has moved; how far the crown has moved and in what directions and combinations of them. Changes in the inclination or angulation become apparent.

We apply this method of evaluation to the upper molars and find its use equally important for them. Changes that take place in the positions of these important "anchor teeth" dictate chapters in the story of anchorage. To apply the method to the upper molar teeth we proceed as follows: superpose the after treatment tracing on the before treatment tracing by superimposing the maxillae as formerly described (Fig. 9-above). Draw a dashed line representing the first molar of the first tracing onto the after treatment record in the following manner: from the tip of the mesial cusp to the tip of the mesial root, draw a dashed line and place a small dot at each end. We will call this line the upper molar line. Viewing the after treatment tracing by itself (Fig. 9-below), you can quickly see the movement that has occurred to this tooth in this plane of space. Changes in its inclination and its vertical height will be particularly interesting, especially in the treatment of Class II malocclusions.

Fig. 9 Above. Before and after treatment tracings superimposed on the maxillae to establish the upper incisor and molar lines. Below, the upper incisor and the upper molar line, recording the original positions of these teeth.

The same procedures can be used with the lower incisors and lower first molars. The line GoGn and the point D have been determined and drawn on both tracings. This line and this point were established on the second tracing from the first one by superpositioning as previously described. It only remains, therefore, to superimpose these lines and points to re-establish this careful superpositioning (Fig. 10-above). Having done so, draw onto the after treatment tracing the graph of the lower incisor from the before treatment tracing by drawing a dashed line as described for the upper incisor. Draw in the graph of the lower first molar by using a dashed black line extending from the tip of the mesial cusp to the tip of the mesial root. Place a dot at each end. View these lines and their relationships to the teeth in their new positions as shown in Figure 10-below.

Fig. 10 Above. Before and after treatment tracings superimposed on the mandibles to establish the lower incisor line and the lower molar line. Below, the lower incisor and lower molar lines which record the original position of these teeth.

These methods can be used on a series of tracings of the same case and, if these lines are recorded on the last tracing, the history of the experience of these teeth will be charted as shown in Figure 11. Evidence such as this is an index to such questions as: the indications for and against and the ultimate effect of tipping molars excessively, and whether or not these tipped molars tend to right themselves at the expense of the roots or of the crowns. In this day of special interest in depression or elongation of the upper molars during treatment, particularly those cases of Class II, Division I malocclusions, this method of assessment gives interesting and important information.

Since anchorage preparation is of concern to many orthodontists and the creation or loss of anchorage is vital to all, it seems desirable that a graphic picture of the conditions made easily discernible by the use of these incisor and molar lines will be stimulating and helpful. These lines do not show anything that is not shown by superimposing tracings, but they do show it more graphically and more quickly and easily.

Fig. 11 Tracing at approximately the end of retention. Dashed lines — original positions of teeth, dotted lines — positions of teeth at end of anchorage preparation, solid lines — teeth at end of treatment.

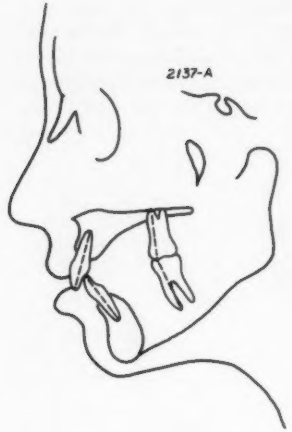


Fig. 12 Above. A typical case showing the incisor and the molar lines (dotted) on the before treatment tracing. Below, the same case after treatment. The lines under discussion show the original position of the molar tooth. Note the bodily movement of the incisor and the tipping of the molar, the price paid for intraoral anchorage only.

Figure 12-above shows a case of double protrusion presenting a serious anchorage problem. Figure 12-below illustrates the case immediately after having what I believe to be a common type of active treatment. It consisted of vigorous and repeated tipping of the anchor teeth and generous use of Class two elastics. Probably no extraoral anchorage was used. It is evident that "the good fight" (if this type is good) had been fought to resist the forward movement of the anchor teeth. A high price of excessive tipping the anchor teeth was paid and a long period of retention is anticipated, for these molars, particularly the upper ones, will erect themselves at the expense of the crowns coming forward. Elongation of the teeth of the upper posterior segments did not occur. Such movement is now sometimes thought to be desirable, particularly in the treatment of Class II cases. Look at the upper molar in Figure 12-below. The dashed line was copied from the before treatment tracing. Its upper end represents the tip of the mesio-buccal root before treatment. Its lower end shows the original

Fig 13 Above, before treatment, and, below, after treatment. Note how these lines tell a different story from the last case. Here extraoral anchorage and anchorage preparations have kept the molars back and nearly erect. The upper one is elongated as is desired by some orthodontists, particularly in Class II treatment.

position of the tip of the mesio-buccal cusp. We see that this cusp has come forward and upward 4 millimeters. The tip of the root has come forward 5 millimeters and the tooth has tipped from its original position 5 degrees.

In like manner the lower molar line demonstrates that the tip of the mesio-buccal cusp has come forward 3 millimeters and elongated 3 millimeters; the tip of the mesial root has tipped forward and upward 8 millimeters and the inclination of the molar has changed 9 degrees. The movement of the upper and lower incisors is obvious.

A similar, but more difficult case is shown in Figure 13-above. "Anchorage preparation" as advocated by Tweed was used. Extensive use was made of head-gear applied by means of the Kloehn-type fixed double-bow. Class III elastics followed by Class II elastics were worn. See the difference in the results achieved (Fig. 13-below). Note the small amount of tipping of the upper molar and the fact that it remained almost in its original position mesio-distally. Notice also its elongation. The lower molar is well positioned to resist the pull of the Class II rubber ligatures and it has not been extruded by them. In both of these cases note the effectiveness of the incisor and molar lines to draw distinction between the results achieved by these two different methods of treatment.

Examine Figure 14 using the incisor and molar lines augmented by some of the incisal and apical base measurements. This case presents a less serious problem but, because the anchorage has been squandered and wasted, the case is a dismal failure. The crown of the upper incisor has been retracted little, the root none. The upper molar has come forward almost bodily. Both the lower incisor and lower molar have come forward and, unforgivably, crown first. Even though four bicuspids were extracted the lines under discussion and the soft tissues tell a story of the wanton waste of

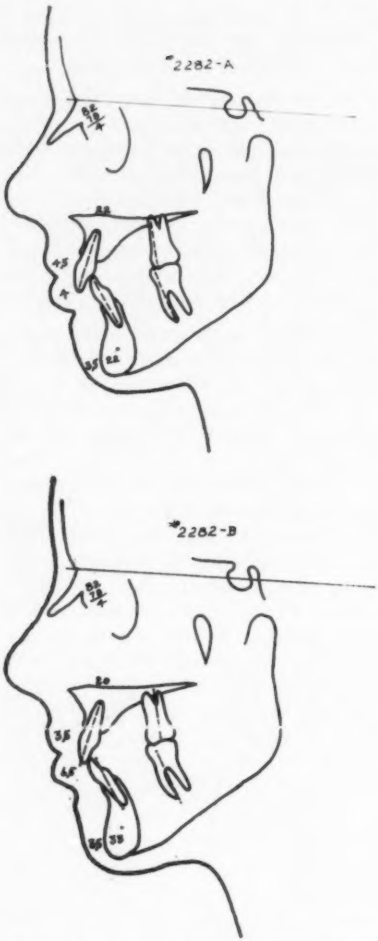


Fig. 14 Above, case before treatment and, below, after treatment. Anchorage was wasted. The case is probably worse after treatment.

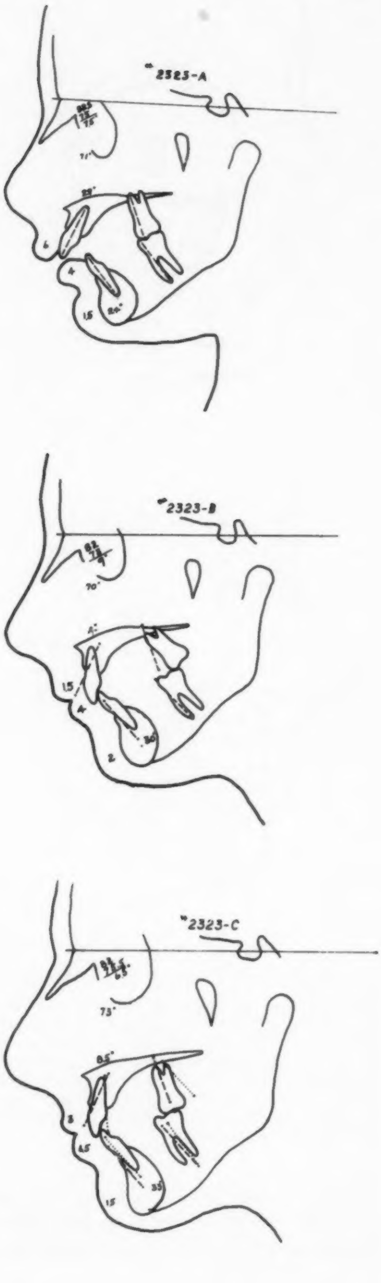


Fig. 15 Above, before treatment. Middle, after eighteen months of treatment with two upper molar bands, Kloehn-type double bow and neck strap only. Note tremendous tipping of the upper molars due to faulty application of pull. Below, four years later. Mother Nature has been kind. This case shows the effectiveness of the incisor and molar lines.

anchorage and of the poor result that was achieved.

The case shown in Figure 15-above has been treated to the stage shown in Figure 15-middle solely with two upper first molar bands and a Kloehn type double-bow used with a cervical anchorage. From the obvious drastic overtipping of the upper molar it is evident that the cervical pull was applied to an outer bow that was too short and doubtless too low. This spectacular movement of the upper molar is, in the writer's opinion, useless and contraindicated. The Kloehn bow and the cervical strap can be equally effective in keeping a molar upright or even tipped in the other direction.

The distal movement of the lower molar as well as the upper one can be seen. We have often observed this effect on the mandibular teeth when using extraoral anchorage against the upper teeth and we believe that this phenomenon is significant, interesting and useful. Note also the distal displacement of the mandible and the angle SND. We believe that this is temporary and will recover when the distal influence is discontinued. Figure 15-below shows the case about four years later. Nature has been kind. This case graphically shows the effectiveness of the incisor and molar lines.

If we are to attempt to evaluate the positions of teeth to one half of a millimeter or to one half of a degree, we must have accurate tracings that represent the teeth. It is my opinion that sufficient accuracy for the purpose of these fine determinations is usually not accomplished by tracing directly from the radiograms.

To solve this problem a plastic template from which all tracings of the teeth are made is very helpful (Fig. 16). In addition to saving time in tracing, it will assist considerably in establishing the outlines of the teeth; it produces a much better looking tracing and assures that serial tracings of the same teeth will be similar and therefore can be compared. Cephalometric measurements are made only on certain areas of teeth usually the labial, mesial and occlusal surfaces, the incisal edges and the long axis. These parts can be accurately traced by the use of a template.

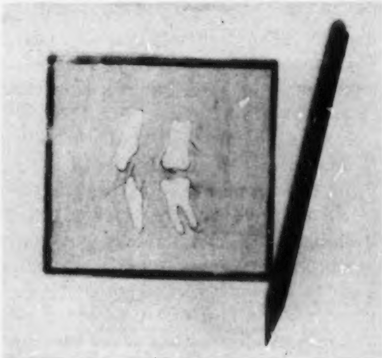


Fig. 16 A plastic template to draw symbols of the teeth which can be duplicated in serial tracings and be compared.

It seems to the writer that methods of evaluating the hard tissues shown in cephalograms have been sufficiently well developed to permit using the information that is available in them to good advantage. Methods for surveying the soft tissues have not been as thoroughly explored. Information regarding these soft tissues is important to orthodontic problems and should be fully used. It is the writer's opinion that, when methods of measuring and integrating the data of the soft tissues are decided upon, they will be similar to those for the hard tissues and they will be predicated upon similar or perhaps identical landmarks. We are now particularly interested in the "E Line" of Ricketts, which is drawn from the tip of the chin to the tip of the nose and also in the "Soft Tissue Line" of Holdaway. This soft tissue line is drawn from the tip of the chin through the

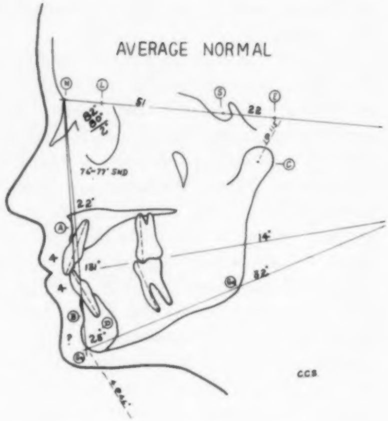
tip of the upper lip and intersects the line SN. Many other attempts to evaluate the soft tissues have been made recently, one of them, published by Stoner and co-workers.[19]

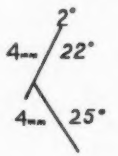
It is apparent that many members of the profession are prejudiced against using cephalometric procedures in their practices because of their lack of understanding of how standard measurements should be used. Downs presented a mean for each measurement he proposed and he also wisely provided plus and minus limits within which measurements of individuals can vary and still be within the normal range. Wylie has made it clear that variations within these limits must occur in the right combinations, if the individual is to be normal. Human judgment is still necessary to decide the desirable combinations of these variations.

Other writers attempting to simplify the presentation of their ideas and thus stimulate their adoption have presented one set of figures as a mean, to be varied by judgment as is indicated for the individual. No one, I hope, has claimed that every individual should conform to one set of measurements.

We chose a revised set of figures graphically shown in Figure 17 which expresses our concept of a normal average American child of average age. These figures can and should be varied for the use of those who have a different concept of what constitutes a "good face." They *must* be varied when malocclusions have occurred. These variations will be not only in the size of the measurements, but also in the ratios between them. Figure 18 shows a chart used by the author to determine these sizes and variations.

As is almost universally true throughout the realm of nature, as soon as a variation from the typical appears in one part of an individual, compensating variations often appear in other parts. Cephalometric standards are





ANB = 2°
⊥ to NA = 4mm
⊥ to NA = 22°
⊤ to NB = 4mm
⊤ to NB = 25°

Fig. 17 Average measurements of normals suggested to be used for comparisons. The graph of the upper and lower incisors shows the measurements of the upper incisor to the line NA and the lower incisor to the line NB. The top figure is the angle ANB.

merely gauges by which to determine more favorable compromises as a treatment goal. For a consideration of what these variations in and between measurements should be under different circumstances, we offer the following suggestions.

Graphically expressed is the normal pattern shown in Figure 19-A. In such a case the angle ANB is 2 degrees, the apical base of the mandible being 2 degrees posterior to the apical base of the maxilla. The upper central incisor to the line NA is 4 millimeters at 22 degrees. The lower incisor to the line NB is 4 millimeters at 25 degrees. The upper and lower incisors then occlude normally.

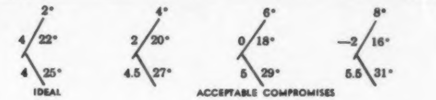
If, as in Figure 19-B, the measure-

Name: ______ No: ______ Age: ______ Sex: ______

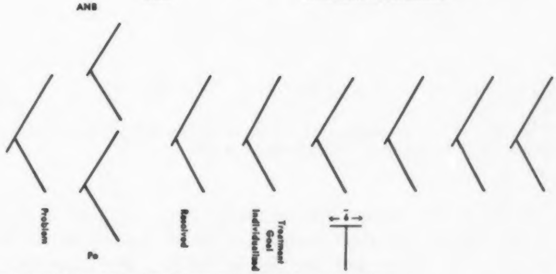
CEPHALOMETRIC ANALYSIS
STEINER

		Ref. Norm.						
SNA	(angle)	82°						
SNB	(angle)	80°						
ANB	(angle)	2°						
SND	(angle)	76° or 77°						
$\underline{1}$ to NA	(mm)	4						
$\underline{1}$ to NA	(angle)	22°						
$\overline{1}$ to NB	(mm)	4						
$\overline{1}$ to NB	(angle)	25°						
Po to NB	(mm)	not established						
Po & $\overline{1}$ to NB	(Difference)							
$\underline{1}$ to $\overline{1}$	(angle)	131°						
Occl to SN	(angle)	14°						
GoGn to SN	(angle)	32°						
SL	(mm)	51						
SE	(mm)	22						
Arch length discrepancy								

(mm)	+	—
Correcting Arch Form Moves $\overline{1}$		



LOWER ARCH	+	—
Discrepancy		
Expansion		
Relocation $\overline{1}$		
Intermaxillary		
Extraction		
Total		



* *These estimates are useful as guides but they must be modified for individuals.*

C.C.S

Fig. 18 A cephalometric appraisal chart showing average measurements of normal cases, presented for comparisons and to determine possible acceptable arrangements of the teeth when the apical base relationship varies from normal. The graph forms at the bottom are designed for diagnostic procedures.

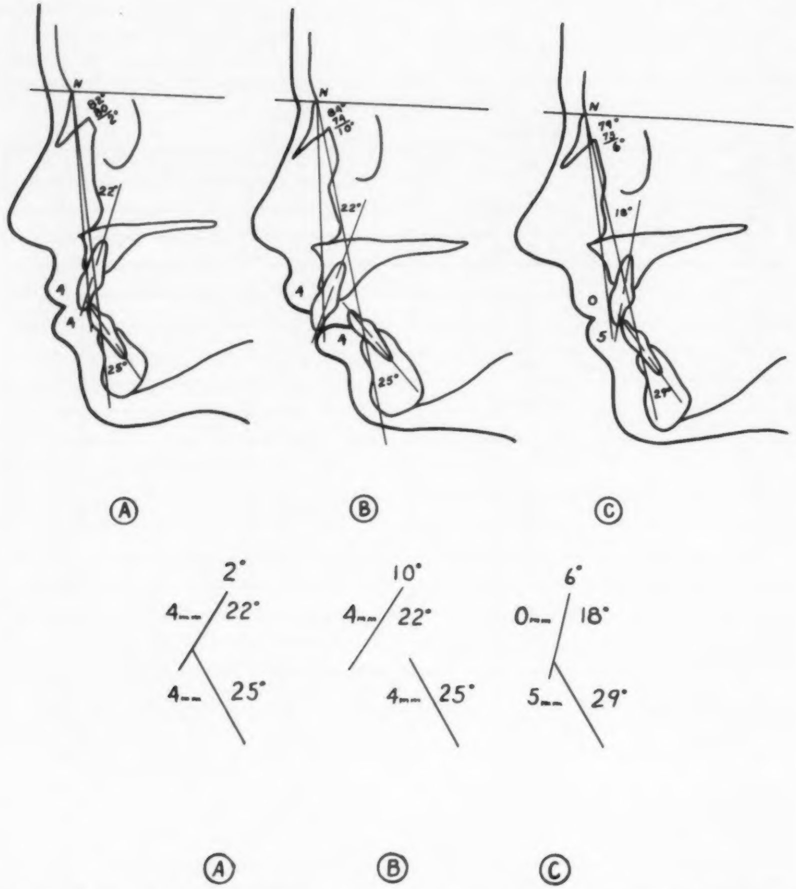


Fig. 19 A — average normal. B — hypothetical malocclusion. C — predicted treatment based on the demands of the angle ANB.

ments of the upper incisor and the lower incisor to their respective lines remain the same, but the angle ANB is 10 degrees instead of 2 degrees (the mandible is then displaced posteriorly in relation to the maxilla), the upper and lower teeth will not meet; instead, the mandibular teeth will occupy a position posterior to the upper ones.

A desirable way to treat the case is to reduce the apical difference from 10 degrees to 2 degrees. This calls for retracting the maxilla and/or developing the mandible forward, each member being restored to its normal size and location. This is generally not possible to accomplish, so a compromise is necessary. From past experience we know that in this particular case we can reduce the apical base difference (angle ANB) from 10 to 6 degrees. Many things influence this estimate;

age, growth potential, type of malocclusion, type of treatment and the ability of the orthodontist are the principal ones. The remaining discrepancy between the upper and the lower incisors must of necessity be treated by a different procedure. The case under discussion has been reduced to an ANB angle of 6 degrees. Figure 19-C will show our suggestions for the placement of the teeth as dictated by this 6 degree angle. The justification for these suggestions will be discussed later. This formula must be altered by other factors and conditions, particularly the relationship of the measurement pogonion to NB and its relationship to the measurement, lower incisor to NB.

As a matter of fact, the measurement, pogonion to the line NB, is probably just as important for a consideration of where to place the teeth

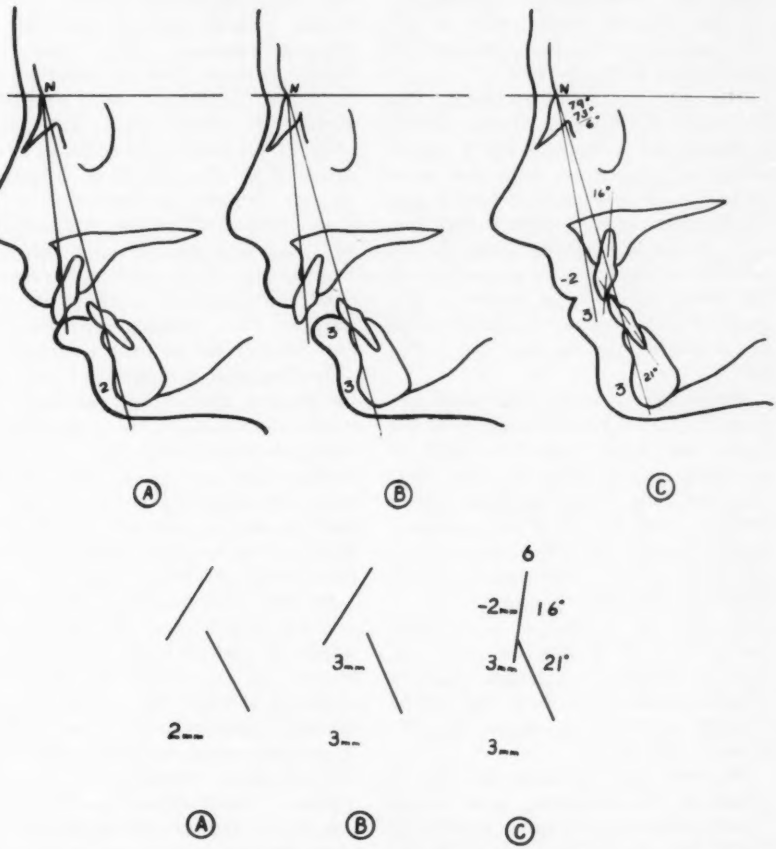


Fig. 20 A — measurement pogonion to the line NB is 2 mm. B — measurement pogonion to the line NB was estimated to change to 3 mm. Lower incisor is placed at 3 mm. to the line NB to be in a 1:1 ration to the measurement pogonion to the line NB (Holdaway). C — predicted treatment based on the demands of the measurement pogonion to the line NB.

as is the angle ANB. Let us therefore re-evaluate the case, this time on the basis of pogonion to the line NB which in this case was originally 2 millimeters (Fig. 20-A). From experience with similar cases we will estimate that because of normal growth, development and treatment therapy, the distance Po to NB will increase in this particular patient from 2 millimeters to 3 millimeters during treatment. Using Holdaway's desired ratio of one to one, between the measurements pogonion to the line NB and lower incisor to NB, our formula for the lower incisors will be as shown in Figure 20-B.

We have previously estimated that the angle ANB would change during treatment to 6 degrees. The 6 degree angle in conjunction with the lower incisor in its new position will dictate the location of the upper incisor, because, under the circumstances, the upper incisor can occlude properly with the lower in only one location, this position being minus 2 millimeters and at 16 degrees to the line NA (Fig. 20-C).

These figures are arrived at as follows: let us accept the positions of the upper and lower incisors dictated by the ANB angle of 6 degrees (Figs. 19-C and 20-C) as being satisfactorily related to each other. If the measurement pogonion to NB indicates that the lower incisor be retracted from this otherwise satisfactory position of 5 millimeters to a position of 3 millimeters, Fig. 20-B, then the upper incisor, to remain in occlusion, must be retracted a similar distance. This will be from 0 millimeters to minus 2 millimeters. (Fig. 20-C).

We have now evaluated the case on a basis of the relationship of the apical bases expressed by the angle ANB (Fig. 19-C) and also on the basis of the degree of protrusion of the chin. (Fig. 20-C). Let us now reconcile the two methods.

Figure 21-A graphically expresses our hypothetical problem. Figure 21-B shows the proposed arrangement of the teeth as dictated by the angle ANB. Figure 21-C depicts the arrangement of the teeth as indicated by the measurement pogonion to the line NB. Figure 21-D shows a reconciliation between the two made by establishing the average between them. We must also take into account many other factors that must be considered such as age, sex, race, individual growth pattern, health, growth potential and the individual variations within these and other variations. Let us therefore adjust these figures as these conditions dictate. On another graph of the teeth (Fig. 21-E) modify the formula to the demands of the individual conditions as your judgment dictates. Let us call it the "adjusted" or the "individualized" treatment goal. See the place on the diagnostic chart marked, Treatment Goal Individualized, provided for this purpose. These adjustments must forever be dictated by human judgment.

For the sake of simplicity I will take for granted that in this particular instance all conditions are typical of the standards from which they came. To modify them and justify the changes would necessitate a lengthy paper in itself. In this hypothetical case, formula 21-E is identical to formula 21-D. In practice this would be unusual.

In effect we now have a prescription for treatment of this case and a standard by which results achieved may be assessed. It is a goal toward which to work, a base from which to calculate progress and a record with which to evaluate what has been done as a basis for future treatment.

From evidence gleaned while studying the relationship of the upper and lower anterior teeth to each other after good results were achieved by orthodontic treatment in cases where the apical bases were in various mal-relationships,

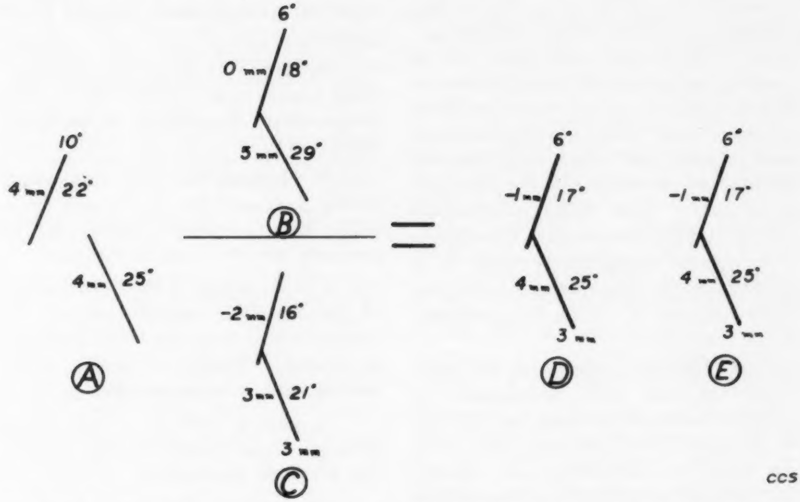


Fig. 21 A — our hypothetical problem. B — the proposed arrangement of the teeth as dictated by the angle ANB (See Fig. 19). C — the arrangement of the teeth as indicated by the measurement pogonion to the line NB (See Fig. 20) D — a reconciliation between Figures B and C, made by establishing the averages between them. E — the "adjusted" or individualized formula. If it is indicated, it has been adjusted for age, sex, race, individual growth pattern, growth potential, health and all other conditions that influence this particular problem.

and also from evidence seen on the drawing board and from large scale models of teeth, we now offer our present estimates for the placement of the upper and lower central incisors as dictated by the angle ANB, in cases where their apical bases are progressively more mal-posed. Figure 22 illustrates these estimates.

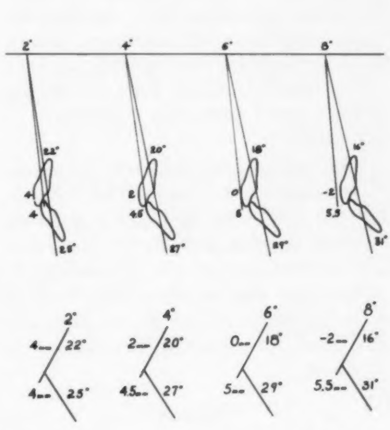


Fig. 22 Our present estimates for the placement of the upper and lower central incisors, dictated by the angle ANB, as the mandible is more distally placed in relationship to the maxilla. These are rough estimates to be used as a starting point from which to vary and must be modified by other factors.

PLEASE bear in mind that these are rough estimates, to be used as a starting point from which to vary and must be modified by other factors, not only pogonion to the line NB, but also age, sex, race, growth potential and the individual variations within these and other groupings. These figures can be tailored by those who use them to fit their own standards of treatment ideals.

I agree with the many who claim that fixed numerical standards should not be used to dictate treatment therapy for living human beings. They can,

however, contribute as guides to the judgment of those with limited experience and they can assist all in reaching individual decisions. Observation has convinced me that treatment therapy based solely upon experience and artistic sense is not infallible nor without its shortcomings. As the Germans say, "Eine hand wascht die andere." (One hand washes the other).

It sounds complicated? Well, it is at first. So is a harmonica until you learn to play it. Then it practically plays itself.

Cephalometric procedures do give important and vital information to guide orthodontic therapy but the answers are not written out with mathematical precision and clarity. A remarkable amount of information is available, however, for those who are willing to put forth the effort to find it. Cephalometric studies can be so rewarding, that I now question the right of orthodontists to offer their services to the public without giving their patients the protection and the benefits made possible by the intelligent use of these principles. I can honestly say that cephalometric findings have practically revolutionized treatment procedures in our office.

The use of cephalometric principles in orthodontics is growing fast. Largely by trial and error, its usage is evolving towards simpler and clearer standardized methods that all can understand. It is my hope that by presenting some of these problems for public scrutiny and appraisal, this paper will contribute to that end.

Summary

1. Point D is a useful landmark and we suggest the use of the angle SND as a basis for evaluating the anteroposterior position of the mandible.

2. We recommend the D line to locate the lower central incisor in the mandible and to assess changes of its position.

3. Approval is given the measurement pogonion to the line NB to help prognosticate the position of the lower incisor teeth.

4. We propose the upper and lower incisor lines and the upper and lower molar lines to evaluate changes in the positions of these teeth.

5. The recording of the entire picture of the mandible and the use of the measurements that we have proposed to evaluate changes in its size, shape and location is recommended.

6. A plea is made for quality and accuracy in x-ray technic and for care and precision in tracings.

7. We implore, that if you have not already done so, you familiarize yourself with the tremendous opportunities that cephalometrics offers in the field of orthodontics, to analyze problems, to determine solutions for them, to evaluate the results of treatment, to improve orthodontic knowledge and thus to enhance our usefulness to humanity.

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Acknowledgements

The writer sincerely desires to give credit for the evolution of these measurements where credit is due. This is not easy for in many instances they are founded upon principles which overlap and these principles are applied in different ways. After seriously trying to separate them and to allocate specific credit for each, he takes refuge in merely stating: "Special credit should be given to Doctors William B. Downs, Allan G. Brodie, Wendell L. Wylie, Richard A. Riedel, John R. Thompson, Reed A. Holdaway and to others for suggesting many of these measurements and for popularizing their usage."

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A Functional Study Of The Palatal And Pharyngeal Structures

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Recent contributions to orthodontic literature have criticized the static approach of examining a denture at rest, with the teeth artificially articulated by means of plaster casts. It is becoming increasingly evident that more consideration must be paid to the role of the musculature.[1] Functional aberrations can create severe morphological disturbances of concern to the orthodontist. Mastication, though important, is not the sole functional entity. Of equal or greater importance are the functions of deglutition, respiration and speech. Perverted perioral muscular activity during swallowing can create severe malocclusions or make existing malocclusions more severe. Relatively little objective research has been done in this field, but it seems logical that abnormalities in respiration and speech may be as important as improper mastication and deglutition by virtue of the muscular forces involved. Speech problems in particular are of concern to the orthodontist. Whether they are causative or resultant of the abnormal morphology conferred by the dental malocclusion, the fact remains that a high percentage of orthodontic patients do have speech defects. In many instances, the parent will say that this is the reason that the child is brought for his initial orthodontic examination. Mouth breathing, hypernasality, and sibilant defects are common sequelae of the Class II, Division 1 malocclusion. In congenital cleft palate patients, speech problems are compounded and the occlusion may or may not be a factor. Because of the difficulty of studying normal speech physiology, controversy exists over the relative importance of the teeth and investing tissues, palatal contour, lip activity, velopharyngeal valving, etc. in the production of normal speech sounds. Since 1950, a series of cephalometric-roentgenographic studies of normal and cleft palate subjects has been directed by Graber at Northwestern University Cleft Lip and Palate Institute. In the past two years, an extensive study of basic normal speech function has been carried out through the support of the United States Public Health Service Research Grant D-405. The project is designed to give an objective, descriptive analysis of the function of the "normal" velopharyngeal mechanism during the instant of production of each of the various types of consonant sounds in American English. The present report summarizes these previous and presently continuing investigations.

In 1950, Williams made a roentgenographic study of vowel sounds in

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thirty non-cleft individuals between twenty-two and thirty-five years of age.[2] This was primarily a study of soft-tissue physiology during vowel tone production, similar to the study done in 1927 and reported by Dr. G. O. Russell in 1931.[3] With improved roentgenographic equipment, finer analysis of soft tissue movements was possible. He noted that the function of the velopharyngeal valve is related directly to tongue function. During the production of the prolonged vowel tones, Williams failed to find any compensatory pharyngeal activity. That is, the position of the posterior pharyngeal wall remained relatively stable at rest and during function. In 1953, Carpenter reported his study of twelve cleft palate patients ranging in age from fifteen to thirty-nine years.[4] These were postoperative subjects with fairly good speech and slightly nasal voice qualities. He repeated the study of Williams. In addition, he added the consonant *k* and had each patient blow into the calibrated manometer tube. The level of air pressure was recorded for each test element. Carpenter found significantly more anterior movement of the pharyngeal wall during production of the consonant sound *k*, and he noted some anterior movement of the posterior pharyngeal wall in the cleft palate cases during vowel production that was not present in the normal sample.

In 1954, Wildman did a detailed metric analysis of a velopharyngeal closure and correlated this directly with nasal emission, as measured on a specially constructed nasometer employing a Marey tambour.[5] Nasal emission was highly correlated with the size of the pharyngeal port. The study corroborated Carpenter's observations of compensatory movement of the posterior pharyngeal wall in cleft palate subjects. Wildman observed a difference in tongue and palate position and the extent of posterior movement of the soft palate in cleft palate subjects, when compared with the normal profile roentgenograms in Williams' study.

In 1951, McDonald and Koepp Baker had reported a tendency in cleft palate patients to talk with the dorsum of the tongue held high in the back of the mouth.[6] They expressed the belief that this was a major cause of hypernasality, nasal emission, and faulty articulation, and that the elevated mandible and the malposed tongue were part of this subnormal functional activity. Objective investigation was done by McKee to test this thesis and was reported in 1955.[7] McKee noted that the tongue position was lower than normal in cleft palate patients. During phonation, these patients elicited a definite posterior movement not found in comparable normals. McKee's investigation also showed greater extent of movement of the hyoid bone during production of speech sounds. Jo Subtelny further corroborated the findings of McKee on the lack of the highriding tongue in a more detailed study.[8] In 1956, Senty, using the new stereocephalostat and a high speed rotating anode radiation source, obtained under the United States Public Health Grant D-280, studied for the first time short duration speech sounds such as *p* and *k*.[9] His analysis of the speech function of seventeen normal speech subjects pointed out the importance of the adenoid tissue as a factor in velopharyngeal function. With this improved methodology, he was able to show anterior movement of the posterior pharyngeal wall even in normal subjects. The frequency of anterior movement was correlated with the sounds being produced and the intensity of the sounds.

In 1957, companion studies by Anderson[10] and Nohrstrom[11] compared soft tissue changes during speech and swallowing functions for cleft palate

and for normal subjects. Their investigations showed that the degree and even the mode of velopharyngeal valving was significantly different for deglutition, as compared with speech. The peristaltic-like action during the act of swallowing for both the normal and cleft palate subjects showed a constant and maximal activity of the tongue, soft palate and associated structures. A much more refined level of muscle specificity was involved in the speech act in both subjects. A significant finding was the fact that some vela, inadequate to supply velopharyngeal valving for speech in cleft palate subjects, showed adequate closure during the swallowing act.

This series of studies indicates the need for a more detailed and limited investigation of the many variables with the use of the new and improved roentgenographic equipment now available. The following is a preliminary report of such a study now underway at the Northwestern University Cleft Lip and Palate Institute.

Present Study

The purpose of the present investigation is to objectively describe and analyze the function of the velopharyngeal mechanism during the instant of production of each of various types of consonant sounds.

A method was developed through a series of preliminary studies on normal subjects using high-speed, fine-focus roentgenographic equipment modified by an instantaneous timer switch and special patient-positioning devices. After the methodology and research plan had been developed and tested through a series of fifty pilot investigations on each of the consonant sounds in American English, this second phase study was initiated. It was limited to the investigation of the velopharyngeal function during the instant of production of the labial sounds *p, b, f, w,* and *m,* since the pilot studies had indicated that the most consistently reliable result could be obtained on these sounds. The purpose of this second phase investigation was to describe functional and morphological changes of the soft palate and related structures from rest position to the instant of production of each of these sounds. The second phase study sample was made up of forty-four young adult subjects from nineteen to thirty-five years of age. Each subject had normal articulation patterns for speech and normal voice quality. Twenty-two of the subjects were male and twenty-two were female. All were college students enrolled at Northwestern University at Evanston or Loyola University, Chicago.

Procedure

After preliminary speech, hearing, and voice tests each subject was positioned in a head-holder designed to standardize all technical variables, to eliminate random movement during the test run and to permit accurate duplication for cross-sectional and longitudinal studies. A Lyshholm-Schoenander polarizing grid and a one and one half millimeter aluminum filtration screen were used to improve soft tissue disclosure and to give added protection to the subjects. Six exposures were taken on each subject in the series, one for the rest position, and one each for the instant of production of the constant sounds *p, b, f, w,* and *m.* Each exposure was taken at a speed of 1/20 of a second at 200 milliamps, and 95 Kvp. Ionization chamber tests indicated .075 to .090 roentgens per test sound which is far below even minimal hazard conditions. Soft tissue visualization was improved through the use of a barium disclosing solution painted on the lips and tongue of each subject. (Figure 1)

Certain additional controls were used in order to eliminate other possible

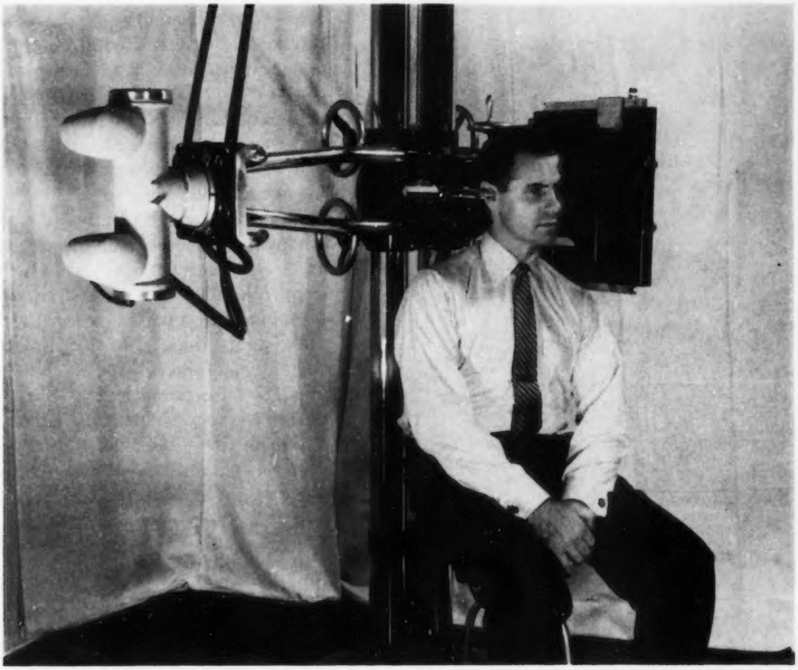

Fig. 1 Stereocephalostat, using high speed rotating anode radiation source and instantaneous exposure mechanism.

variables in the production of the speech sounds. A standard carrier phrase "Now I say the word" was used in each case followed by a nonsense syllable initiated with the test sound. In order to eliminate the possible effect of the vowel tone upon the palatal position of the consonant sound tested, four different vowel sounds were used after the test sounds. The vowels selected for this purpose were *e* as in the word *see*, *a* as in the word *father*, *a* as in the word *caught*, and *oo* as in the word *new*. In order to control possible differences in the force of the speaker's voice, an Altec 660B microphone attached to a PT-6 Magnicorder hi-fidelity tape reproduction system was placed exactly six inches from the lips of each subject. (Figure 2) Each subject monitored the force of his voice so that a VUmeter on the recorder peaked at -3 on the test syllable. Each subject repeated the carrier phrase and test syllable three times, monitoring the force of their voices. The exposure was timed to coincide with the lip articulation of the consonant sound being tested. Tape recordings were made of the entire procedure and each subject, and were played back to double-check the timing of each exposure. This was possible because the sound of the cathode-ray discharge was audible on the tape. Cases with imperfect timing were eliminated from the study sequence.

The salient structures were traced directly on the headplate by each investigator. Following this, superimposed

Fig. 2 Subject positioned by calibrated ear-rods and orbitale markers. The high-fidelity Altec 660B microphone is mounted exactly six inches from the lips at rest.

tracings of all test exposures were made. (Figure 3) Different colors were used for each test sound to prevent confusion in interpretation. Accurate millimetric measurements were made of the outline of the velum along the superior border, from the posterior nasal spine to the uvula. The velum was divided into quadrants for all tracings. Posterior pharyngeal wall contiguent structures were outlined. Specific measurements were made of the length of contact of the pharyngeal wall and the velum and of the extent of forward movement of the sphincter complex. The height of the velum during function was determined with reference to the palatal plane. Data were compiled on master charts and subjected to biometric analysis in an attempt to answer the following questions:

1. How long was the palate at physiologic rest and what changes occur in palatal length during function?
2. Which quadrant of the palate most consistently contacts the posterior wall during velopharyngeal valving for speech?
3. What is the length of upward and backward movement of the palate at each quadrant and at which quadrant does the greatest extent of movement take place?
4. How high does the soft palate rise during speech?
5. What is the midpoint of closure of the velopharyngeal valve?
6. What is the consistency of complete or incomplete valving for the various test sounds?
7. What is the superior-inferior extent of contact of the velum and posterior pharyngeal wall at the moment of contact?
8. With what frequency does forward movement of the posterior pharyngeal wall take place?
9. Is there a consistency to the morphology of these structures during speech or is there a difference for each of the test sounds?

Data and Interpretation

With regard to changes in the length of the palate from rest to functional positions for speech, Figure 4 shows the findings for the forty-four cases in this investigation. It is obvious from this figure that there is a significant increase in the length of the palate from rest to the functional position. As Figure 4 illustrates, the length of the palate at rest ranges from 32 to 49 mm. In contrast, the range for the *p, b,* and *f* sounds which, by their nature require the firmest velopharyngeal closure, was from 45 to 70 mm. In the study sample, Case Three and Case Forty-two illustrate the extreme changes in palatal length from rest to

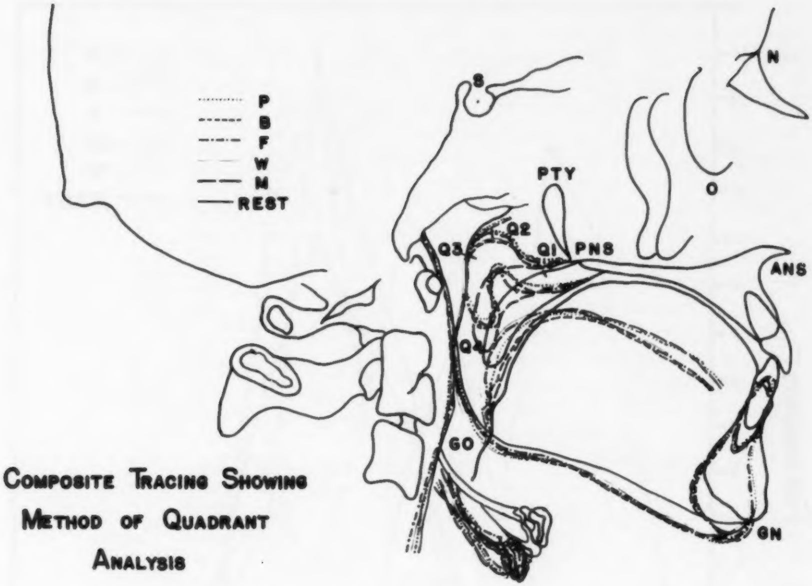

Fig. 3 Typical cephalometric lateral tracing showing palatal, tongue, postpharyngeal wall, mandibular and hyoid bone positions for each of the six test elements. The superior surface of the soft palate has been divided into quadrants to permit a more definitive study of palatal function.

functional position. At rest, the palate of Case Three measured 32 mm. in length. In function, on the *p* and *b* sounds, the same palate measured 57 mm. In Case Forty-two, the palate which measured 32 mm. at rest, changed to a length of 62 mm. on a *p* sound and 63 mm. on the *b* sound. In all cases, the changes in length for the *p*, *b*, and *f* sounds were closely similar. Changes in length on the *w* sound were also similar but tended to be somewhat less than for the other three sounds. Of significance was the increase in palatal length found during the production of the *m* sound. Although the *m* sound is made by emitting air through the velopharyngeal port, the palate does assume a close-ready position of closure which is actually more similar to closed position than the rest position. This fact is objectively substantiated by this and other measurement findings. These measurement changes in length are not interpreted as meaning actual incremental increase, but rather as evidence of the incorporation of tissue elements from the lateral pharyngeal walls.

A highly significant finding resulted from the measurement of the quadrant of contact of the palate with the postpharyngeal wall during speech function. Although in the past it has generally been assumed to be the middle third of the palate which effects the velopharyngeal seal, this evidence showed conclusively that for young adults it is the third quadrant which effects this seal. The third quadrant was involved in the seal in 100% of the cases for the study sample. Quad-

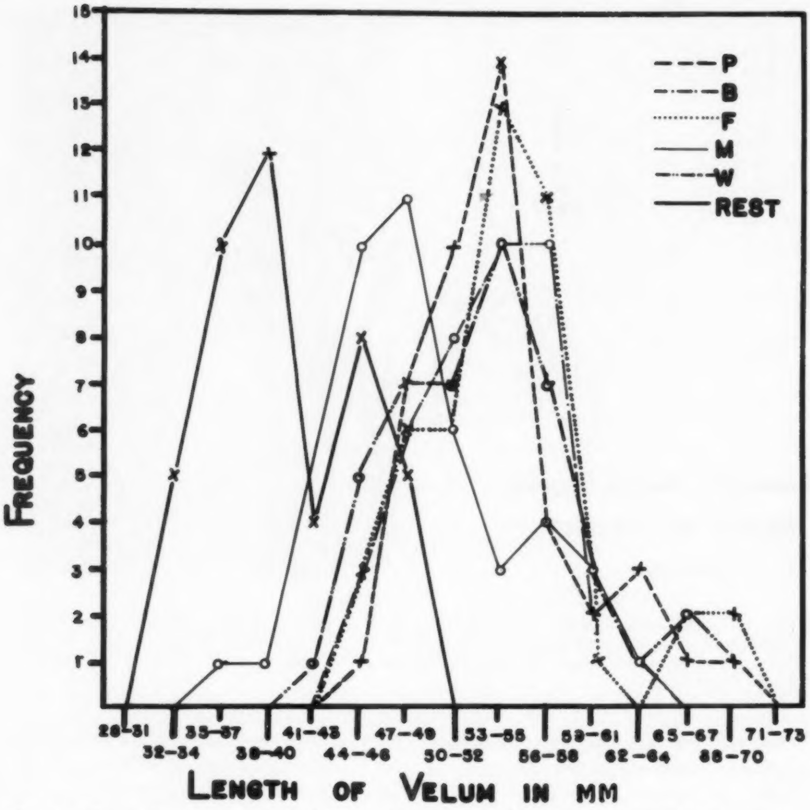

Fig. 4 The resting lengths and functional increments for all cases are plotted on this graph. Note the significant increase in palatal length for all test sounds.

rant four was also involved in the seal in 27% of the cases. Figure 4 illustrates typical quadrant division in contact found in the study.

Table 1 shows the findings regarding the extent of upward and backward movement of the palate at each of the quadrants measured. A consistent finding in this data indicates that Q2, the midpoint of the palate, shows the greatest extent of upward and backward movement from rest to closed position. Despite the magnitude of movement at Q2, the region of the midpoint of the palate was not involved in actual contact with the posterior pharyngeal wall. The second most extensive upward and backward movement was found in Q3, which was involved regularly with velopharyngeal seal. A wide range of angular measurements was found illustrating the direction of movement of the palate of each subject. Table 2 lists the angles described by the intersection of Line Q2 at the palatal plane. The wide range of measurements may be attributed to individual differences of cranio-facial morphology. In all cases, direction of movement was upward and backward.

EXTENT IN MM OF UPWARD & BACKWARD MOVEMENT OF THE SOFT PALATE

Quadrant	*Phonation*	*Mean*	*S.D.*	*Range*
Q1........	P	6.0	2.06	3.0- 9.0
Q1........	B	6.1	2.25	3.0-10.0
Q1........	F	6.0	2.35	2.0-10.0
Q1........	PBF	6.0	2.22	2.0-10.0
Q1........	W	5.8	2.56	2.0- 9.0
Q1........	M	3.9	2.09	1.0- 8.0
Q2........	P	16.2	3.41	10.0-27.0
Q2........	B	16.2	3.40	9.0-23.0
Q2........	F	16.2	3.01	9.0-23.0
Q2........	PBF	16.2	3.27	8.0-27.0
Q2........	W	15.4	3.18	8.0-22.0
Q2........	M	10.2	3.01	2.0-17.0
Q3........	P	14.2	3.42	7.0-20.0
Q3........	B	14.1	3.02	8.0-20.0
Q3........	F	13.7	2.81	6.0-19.0
Q3........	PBF	14.0	3.10	6.0-20.0
Q3........	W	13.6	3.61	6.0-20.0
Q3........	M	9.7	3.38	2.0-17.0
Q4........	P	10.0	3.77	2.0-19.0
Q4........	B	10.0	3.38	4.0-16.0
Q4........	F	9.6	3.23	3.0-16.0
Q4........	PBF	9.9	3.46	2.0-19.0
Q4........	W	9.5	3.15	3.0-17.0
Q4........	M	6.7	3.32	1.0-13.0

Table 1 The greatest upward and backward movement occurs at Q2, or the midpoint of the superior palatal surface. Movement at Q3 was only slightly less, but uniformly contacted the postpharyngeal wall.

Figure 5 shows the findings regarding the high point of the soft palate during speech and the midpoint of closure. It is significant that in all sounds, particularly the nasal, the high point was above the level of the floor of the nasal cavity. The same figure shows that the midpoint of closure is somewhat below the level of the palatal plane, but the high point of the actual seal in most cases approximated the level of the nasal floor. This has clinical implications regarding the placement of the prosthetic speech bulb and the attachment of the pharyngeal flap in certain surgical procedures in cleft palate rehabilitation.

The pharyngeal valve was consistently closed for the consonants *p, b, f,* and *w*. This finding is at variance with other studies, using more static roentgenographic techniques.

The superior-inferior extent of con-

ANGLE DESCRIBED BY MID-POINT OF PALATE IN FUNCTION

Phonation	*Mean*	*S.D.*	*Range*	*Mode*	*Number*
P ...	56.0	5.68	26-76	52	42
B ..	52.6	5.07	24-73	58	44
F ..	52.8	5.09	23-71	58	44
W ..	51.6	2.69	23-73	48	44
M ..	44.2	2.44	27-66	41	43

Table 2 Quadrant markings at rest and during phonation for each sound were joined. The intersection of these lines with the palatal plane formed the recorded angles. The relatively small standard deviations for w and m suggest greater constancy of position for these consonants, but the broad ranges reduce the significance of any interpretation.

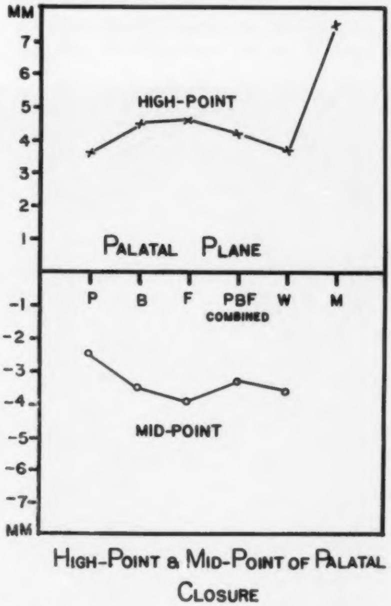

Fig. 5 The highest point of palatal elevation (Q2) was consistently above the floor of the nasal cavity. The midpoint of velopharyngeal valving was 2.4 mm. below the nasal cavity floor. This is higher than generally described.

DISTANCE OF VELUM CONTACT

Phonation	*Mean*	*S.D.*	*Range*	*Number*
PA ..	8.94	3.93	2.0-17.0	42
BA ..	9.85	3.96	3.6-20.0	42
FA ...	11.06	4.43	4.0-21.0	41
WA ..	10.40	4.48	3.8-18.0	40

Table 3 Palatal postpharyngeal wall contiguity during consonant phonation.

tact on these sounds ranged from 2 to 21 mm. Table 3 shows the range, mean and standard deviation for the sample. Despite the broad range, there is a relatively narrow standard deviation and closely similar mean length of contact for different test sounds.

The posterior pharyngeal wall moves forward in more than 50% of the cases. Dramatic constrictor activity assisting in normal velopharyngeal valving was observed in at least four patients. Figure 6 is an example of extreme anterior movement of the so-called "Passavants pad". These findings were interpreted as indicating that, at least in some cases, normal velopharyngeal valving was assisted by significant, superior constrictor activity. However, in the majority of these cases, the anterior component was minimal.

From observation of the consecutive headplates on each individual case, it is obvious that a high degree of consistency of morphology of the velopharyngeal structures is found during the act of speech. There appear to be varying soft tissue contours from case to case, but, despite this, precise measurements of the valving act, as reported above, show a close similarity for all cases.

SUMMARY AND CONCLUSIONS

A review was given of the series of related research studies on speech

Fig. 6 Dramatic "Passavant's pad" activity, white female, with normal speech. This anterior bulging of the postpharyngeal wall was evident for all test exercises in this subject.

physiology carried on by the Northwestern University Cleft Lip and Palate Institute. In general, these studies indicated that anterior movement of the posterior pharyngeal wall is more common in cleft palate than in normal subjects during the production of speech sounds. Studies involving consonant sound elements did show some pharyngeal activity even for normal subjects. It was objectively established that nasal emission and hypernasality were highly correlated with the size of the velopharyngeal port. Aberrant tongue position in function was noted in the cleft palate cases. Metric analysis showed that tongue position was actually lower in the cleft palate than in the normal subjects. The principal variation from normal activity in the tongue function of cleft palate patients was in the nature of a posterior positioning. Other studies showed a significant difference in velar valving for deglutition as compared with speech.

A research study based upon these previous investigations was outlined. Using high speed roentgenographic equipment, the soft tissue morphology of normal subjects was studied during the instant of production of various consonant sounds (*p, b, f, w, m*). Biometric analysis was made of the roentgenographic findings and the following conclusions were drawn: the soft palate increases significantly in length from the rest to functional position. It is the third quadrant of the palate which consistently effects the velopharyngeal seal for normal young adults. The greatest extent of the upward and backward movement of the palate takes place at the midpoint of the posterior superior surface of the palate. The mean extent of movement at this point is approximately 16 mm. The high point of the soft palate is consistently found to be 4 to 5 mm. above the level of the palatal plane during valving. For the nasal sound "m", the high point was found to be 3 to 4 mm. higher than for the remaining consonant test elements. The high point of the soft palate was never involved in actual velopharyngeal seal. The midpoint of closure during velopharyngeal seal is normally 3 to 4 mm. below the palatal plane. The high point of seal is found approximately at the level of the palatal plane. The velopharyngeal valve is consistently closed for all of the consonant sounds during normal speech production. The palate assumes a close ready position of velopharyngeal closure even for the nasal sounds. Slight anterior movement of the posterior pharyngeal wall is seen in over 50% of the normal cases. Dramatic anterior movement occasionally occurs in normal subjects. Metric analyses show that there is a consistent pattern of velopharyngeal valving for speech for normal subjects.

The orthodontist, as well as the prosthodontist and speech therapist, should profit from a better appreciation of normal speech physiology.

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Case Report

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At the time of examination this seventeen year old boy possessed good general and oral health. His malocclusion was classified as Class I. Except for the maxillary incisal area, case exhibited well-developed upper and lower arches with normal well-balanced buccal occlusion. The upper anterior teeth from the left cuspid to the right lateral incisor had been deflected to the lingual and were almost entirely hidden by the mandibular incisors and cuspids. There was more than a millimeter of space between the lower cuspids and first bicuspids.

Etiology

Evidently, prolonged retention of the upper deciduous teeth had forced the upper incisors and left cuspid to erupt to the lingual of the mandibular incisors. This, in turn, carried the six lower anterior teeth labially and created a space distal to the lower cuspids. The overbite was in reverse. The lower incisors and left cuspid covered the entire labial surface of the same teeth in the maxillary arch.

Plan of Treatment

First, it was necessary to open the bite before bands could be placed on the upper incisors, as they were in close contact to the lingual of the lower incisors. Next, the upper incisors and left cuspid should be moved into proper arch alignment, until they are in labial relation to the lowers. Finally, after accomplishing this and allowing the teeth to close normally, the spaces between the lower cuspids and first bicuspids should gradually close without appliances.

Appliance Therapy

The plan of treatment was carried out as follows — first, a splint, as shown in Figure 1, was constructed by placing the casts in occlusion on an articulator which was adjusted to open the bite in the incisal region about seven millimeters. Steel clasps, .030, were fitted to the lower first molars and a lingual bar fashioned by bending a

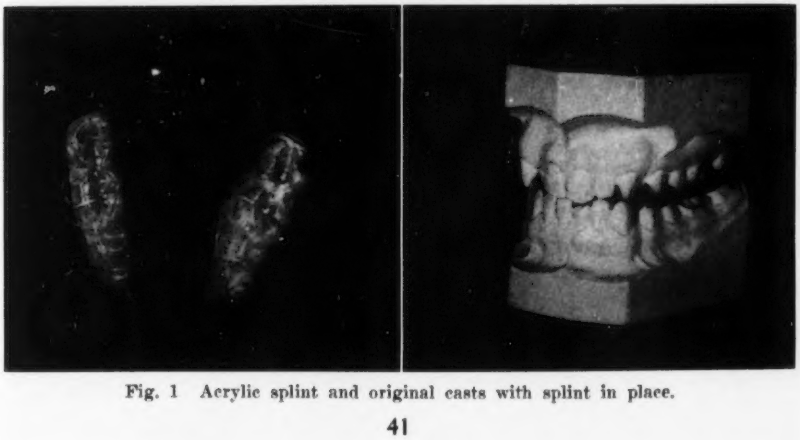
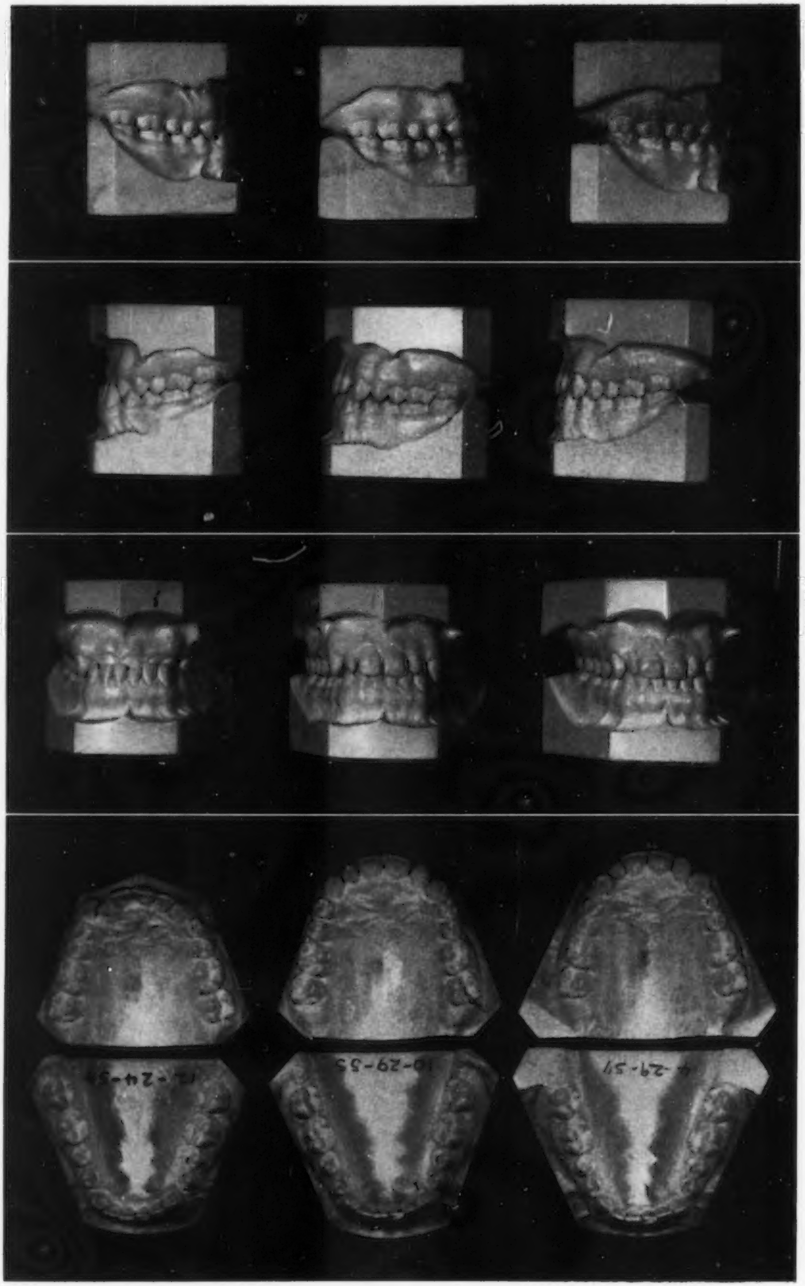


Fig. 1 Acrylic splint and original casts with splint in place.



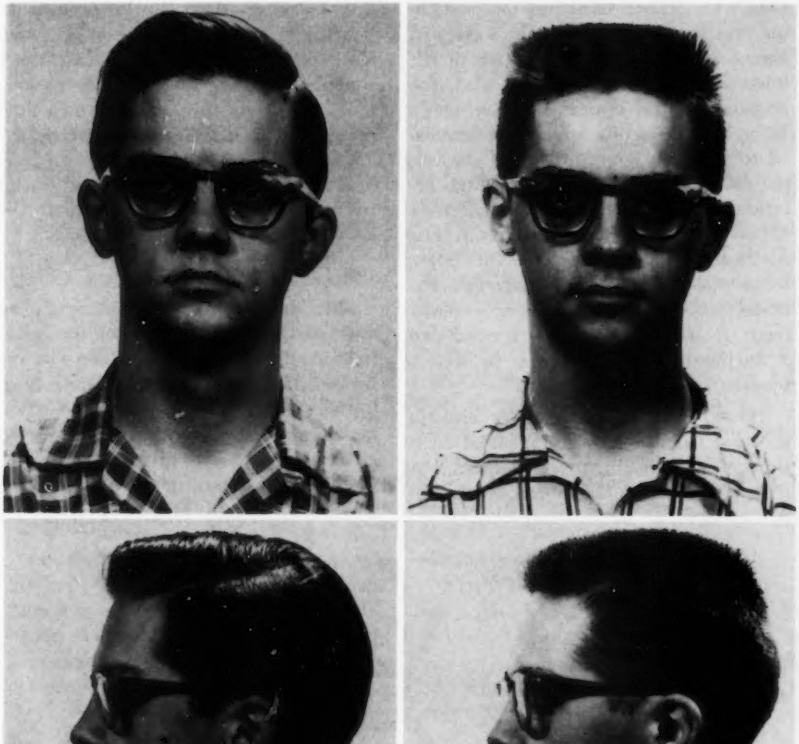


Fig. 3 Left, before treatment. Right, after treatment.

Fig. 2 Left, before treatment. Center, at end of active treatment. Right, twenty months after removal of appliances.

steel wire .055 in diameter (not touching the lower incisors). The case was waxed to fit the occlusal fourth of the lower bicuspid and molars and the occlusal of the upper posterior teeth. From this, an acrylic splint was processed to be worn constantly until the upper incisors were in normal occlusal relation. An edgewise appliance was placed on the *upper arch only* from first molar to first molar. With the bite open, there was nothing to antagonize the labial movement of the upper anterior teeth. As a result, they were moved into a harmonious arch relation in a few months.

When these teeth were far enough forward to close in normal labial relation to the lower incisors, the splint was removed. The labial relation of the upper incisors to the lowers soon closed the spaces distal to the lower cuspids. When the upper bands were removed, after ten months of treatment, there was some spacing of the upper incisors to conform to the lowers which had previously been carried labially by the upper teeth.

No retention was used and after twenty months the spaces distal to the lower cuspids had entirely closed.

Comment

Due to the fact that the upper lip covered the incisal fourth of the lower incisors, there was little change in the lip position. The case would have been difficult to treat without the splint; however, with the splint, it proved to be quite simple with no lower appliance and without retention.

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Cephalometric Analysis Of Treatment With Cervical Anchorage*

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The primary purpose of this study was to determine the facial skeletal changes which occur during treatment with the full edgewise appliance plus cervical traction. The cases recorded were classified as Class II, Division 1 and Class I with Class II tendencies, all without extractions. The neckband appliance was the prime motivating factor for reduction of the Class II relationship or tendency.

Much of the credit for the widespread revival of extraoral anchorage is due Kloehn. His work, as first reported at the meeting of the Mid-western Component of the Edward Angle Society of Orthodontia, 1947, made members of the profession aware of the value of cervical traction in a private practice. Kloehn stressed the guidance of growth and the conservation of mandibular anchorage made possible with the cervical gear. The cases discussed in this paper were treated with these fundamental aspects in mind.

Thirty-four individuals are represented: seventeen boys and seventeen girls. Six of the boys and six of the girls had two periods of treatment, a preliminary period with the neckband appliance only, and a second period with a full edgewise appliance added. The mean starting age for the preliminary period was ten years while the mean treatment time was eleven months. The second period of treatment for the children in this group averaged fifteen months; the total mean time for the two periods combined was twenty-seven months.

For the eleven boys and eleven girls who were treated in one period, the mean starting age was thirteen years, and the mean treatment time eighteen months.

Tracings of before and after treatment lateral head x-rays were made. All angular values were read with a standard protractor and lineal measurements were determined with millimeter rule. The Frankfort plane of each original tracing was transferred to the second by superimposition of the SN plane registered at S.

The following angular measurements were made: SNA, SNB, SNPo, NAPo, NSGn, the angle of the palatal plane to a perpendicular projected from S-N, and the mandibular plane angle according to Downs.

The linear measurements were: SA and SB.

Perpendiculars were projected to the Frankfort plane from points S, A, and B and the distances from S to A and B measured in millimeters. The point S was selected as a base from which to measure because it has been established as one of the most stable points of reference in the head.

Class I cases demonstrating a Class II tendency were included with the Class II, Division 1 cases in this study because therapy was identical. Furthermore, Lande[8] showed the same general tendencies in growth behavior regardless of type. Silverstein[10] concluded that in his sample there was no significant difference in growth trends be-

*Presented before the Mid-western Component of the Angle Society, Indianapolis, January, 1958.

tween untreated Class II cases and untreated normals.

Anterior Maxillary Alveolar Process

Previous Findings

Brodie[1] in his study of growth changes from the eighth to the seventeenth years showed that the conformation of the anterior surfaces of the alveolar process of maxilla and mandible change little or "drop back".

Lande[8] evinced relative stability of the anterior maxillary area in untreated cases. He went further to confirm Brodie's observation that the alveolar growth did not keep pace with the growth of its skeletal base in a horizontal direction. Both substantiated the findings in this regard of earlier workers.

Ricketts[9] in an unpublished study of untreated Class II, Division 1 cases discovered very slight if any change in point A.

Carlson[2] in an unpublished thesis studying ten boys and ten girls with excellent occlusions showed a slight increase in SNA from ages eight to seventeen, the increase being greater in males than females. Clements[3], also in an unpublished thesis, measuring twenty-one males and fifteen females with good to excellent occlusions saw a significant increase in SNA in males between eight to twelve years and in girls between ten and twelve.

Silverstein[10] found that SNA tended to decrease in males with treatment but not in females. Graber[4] spoke of treatment cases in which maxillary alveolar growth was apparently held back by extraoral appliances.

Stoner[11], and co-workers using a linear measurement demonstrated a reduction of point A in cases treated by Tweed. King[5] showed a similar reduction with cervical traction. Klein[6] after measuring SNA writes of an average retraction of 1.3° in cases treated with cervical anchorage. Eight of his twenty-four cases yielded no change.

Present Findings

In the boys in this study the greatest change in SNA was reduction of 4.5°, the least .5°, and the mean 1.86°. In the girls the largest decrease was 7°, the least .5°, and the mean 2.39°. It must be noted that the average reduction in the girls without the unusual high of 7° would have been 1.96°, which is still higher than the mean for the boys. There was a reduction in fifteen of the seventeen boys and fourteen of the seventeen girls.

Only one individual, a boy, in the thirty-four total cases showed an increase in SNA (2.5°). The before and after readings remained the same for one boy and three girls. In summation there was an SNA reduction in twenty-nine of thirty-four cases; the angle remained the same in four cases, and increased in one.

Linear Measurements of Point A

The SA distance along Frankfort plane decreased in eight of the seventeen boys, twelve of the seventeen girls. The greatest decrease in the boys was 3 mm., the least .5 mm., the mean 1.5 mm. The largest decrease in girls was 4 mm., the smallest .5 mm., the mean 1.66 mm.

The distance from S to A increased in nine boys and in only three girls. The high increase in the boys was 4.5 mm., the low .5 mm., the mean 2.38 mm. The high in the girls was 4 mm., the low 1.5 mm., and the mean 2.66 mm. Two of the girls remained the same.

Discussion

There appears to be no correlation between a decrease of the angle SNA and a decrease in the S to A linear measurement.

Our findings bear out those of the other workers quoted who have found that treatment does influence the angle SNA and the point A. In this instance, we have shown that the forward growth of the maxillary anterior alveolar process was restricted in full edgewise appliance cases using the neckband appliance as the restraining force.

It would appear also from our measurements that this alveolar process may be more readily held back with cervical traction in girls than in boys. Or, it may be said that the forward growth tendency in boys is greater than in girls; that the resistive force of the neckband appliance has more to withstand or overcome in the male.

This is a different concept from that expressed by Silverstein who found a treatment decrease in SNA in males but none in females. It is the opposite idea, also, from that of King who found the greatest change in point A in males. Silverstein's report included seventy-four Class II cases (forty more than this sample) in which it is presumed the chief reducing agents were Class II elastics. King reported fifty Class II, Division 1 cases (sixteen more than this paper), both extraction and nonextraction with a greater age range, and some of his cases did not have full edgewise appliances in addition to the neckband appliance.

On the basis of the findings in the smaller sample reported here and with the conclusions of Carlson and Clements in mind (that SNA increases more in good occlusion males than females) I submit the opinion that:

1. Cervical traction may retract or hold back forward change of the maxillary anterior alveolar process more in nonextraction girls than in nonextraction boys because females do not have as much forward growth force.

2. Some of the greater forward growth force potential in boys may express itself in spite of the restraint of cervical traction.

3. If concepts 1 and 2 should be true, then boys, ideally, ought to wear the neckband appliance twenty-four hours a day, whereas the girls, having less growth to hold back, should need to wear the appliance only twelve to fourteen hours daily. This might be true if the end result of treatment was concerned only with reduction of point A. However, the comparatively greater forward growth at other facial points compensates for this relative difficulty in restraining point A in the male.

Mandibular Anterior Alveolar Process

Previous Findings

Lande found no significant change in point B from seven to twelve years, but a mean forward movement of 2.2 mm. from twelve to eighteen years. SNB was not affected by treatment Silverstein observed, while Stoner and his co-workers found a mean forward movement of .08 mm. in the fifty-seven consecutively treated Tweed cases.

Carlson found an increase in SNB from eight to seventeen years. This increase was greater than the SNA increase and more in males than females. Clements reported an increase in SNB in both males and females.

Present Findings

The angle SNB increased in nine boys, decreased in four and remained the same in four. It increased in eight girls, decreased in seven and remained the same in two.

In boys the high increase was 2°, the low 1°, and the mean 1.27°; girls had a high increase of 2.5°, a low of .5°, and a mean of 1.5°. The greatest male decrease was 1°, the lowest .5°, the mean .87°, while the greatest female decrease was 1.5°, the lowest .5°, and the mean .85°.

Linear Distance of SB

The SB distance increased in thirteen boys, decreased in three and remained the same in one. It increased in ten girls, decreased in five, remained the same in two.

The high increase in the boys was 7 mm., the low .5 mm. and the mean 3.38 mm. with a high increase in the girls of 6 mm., a low 1 mm. and a mean 2.65 mm.

Boys' greatest decrease was 2.5 mm., the low .5 mm. and the mean 1.33 mm. The greatest decrease in the girls was 4.5 mm., the low .5 mm., the mean 1.4 mm.

Discussion

The measurements of SNB change with this treatment would indicate that this angle is just as likely to either decrease or stay the same in both sexes, as it is to increase. Seventeen of the total cases decreased or stayed identical while seventeen increased. The big difference was the fact that the mean increase was greater than the mean decrease.

With regard to the SB linear distance there is a decided statistical advantage on the side of the increase. Twenty-three of the total showed an increase, while eleven decreased or stayed the same. The increase was greater in the boys than in the girls. The mean decrease was similar in the two sexes.

A comparison of the results of the angular and lineal measurements related to point B indicates that much of the forward growth of the mandibular anterior alveolar process may be masked in the angular measurements by the forward growth of point N. The SB measurements show that B moves forward predominantly in both sexes but more in boys than girls. This would tend to confirm the findings of Lande, Stoner et. al., Carlson, and Clements.

It would appear likely that point B was affected very little, if any, by treatment as Silverstein noted. However, where there was a decrease in the SB distance or where it remained the same, the bite opening effects of treatment may have had some influence. This would tend to corroborate King when he said that such bite opening apparently occurred in individuals who grew little or none at all, and that this opening resulted in a downward and backward displacement of the mandible.

SNPo

Previous Findings

Lande found that there was an increase in mandibular prognathism generally occurring beyond seven years of age.

Brodie in measuring SNGn showed a predominantly forward movement of the chin point of three to six degrees. Four of his nineteen cases remained the same.

An increase in SNPo in untreated males and females was noted by Silverstein. In the analysis of treated cases he concluded that the forward movement of pogonion was inhibited in both sexes to the extent that the expected growth potential was not attained.

Stoner and his group in their linear measurements of point Po found that it moved forward more than six times farther than point B; King concluded that forward growth of pogonion was disappointing in all his treatment groups except nonextraction males.

Present Findings

The angle SNPo increased in ten boys, decreased in three and remained the same in four. It increased in nine girls, decreased in five, and stayed the same in three. Nineteen of the entire group had an increase, eight had a decrease, and seven remained the same.

The boys showed a high increase of 3°, a low of 1°, and a mean of 1.65°. The girls evidenced a high increase

of 3.5°, a low of .5°, and a mean of 1.55°.

The three boys who showed a decrease were identical with 1° each, while the greatest decrease in the girls was 1°, the least .5° and the mean .8°.

Discussion

It is regrettable that the plan for this paper did not include a lineal measurement of SPo. The interesting findings brought out by comparison of the angular and linear measurements of points A and B dictate inclusion of SPo in a contemplated revision of this work.

The interesting factor, however, in the measurements of SNPo is the similarity of behavior in the two sexes. Not only were the numbers of boys and girls in each category nearly the same, but also, the high, low, and mean measurements were practically identical.

Furthermore, the changes occurring in SNPo were much like those of SNB, as to numbers of individuals in each category and all measurements. There seemed to be a slightly greater quantity of increase in point Po than B, but in the instance of decrease the quantity was equable.

The fact that in the decrease cases the angles SNB and SNPo were reduced similarly could lend further strength to King's expression of the bite-opening effects of treatment in poor growth cases. This may also be further evidence to confirm Silverstein's conclusion that forward growth of pogonion can be inhibited by treatment.

NAPo

Previous Findings

One of Lande's chief conclusions was that the convexity of the face nearly always decreased. It will be recalled that this was in a study of thirty-four cases, ten of which had Class II denture relationships.

Carlson noted that the facial profile became less convex with growth and that this straightening was greater in males than females. He found that this decreased convexity was associated more with an increase in face height than a change in the sagittal relation of the jaws.

In this regard King mentioned that his treatment cases exhibited downward growth in excess of forward growth.

Klein, in his twenty-four cases treated with cervical traction, noted a range of decrease in the angle of convexity of 0° to -7° with a mean reduction of 2.8°. He mentioned the significance of this change since the majority of his cases evidenced an opening of the Y axis; and further, the chin appeared less prominent in some cases as a result of bite opening or growth.

Present Findings

Of the entire thirty-four cases, thirty-three showed a decrease in convexity; and one remaining case — a boy — remained the same. Therefore, sixteen boys had a decrease as did all seventeen girls.

The greatest decrease in the boys was 9.5°, the low 1°, and the mean 4.93°. The largest decrease in the girls was 16°, the least .5°, and the mean 5.08°. Eliminating the unusual high of 16° in the girls, the high would have been 9°, and the mean 4.37°.

The convexity reductions of the six boys and six girls who had two periods of treatment (1st—neckband appliances, 2nd—neckband appliances plus full edgewise appliances) were then separated from the group. It was found that the high reduction for the six boys was 9.5° the low 2.5°, the mean 5.66°; for the six girls the greatest reduction was 7°, the low 1.5°, and the mean 4.66°.

The ten boys showing reduction and having just one period of treatment showed a high decrease of 8°, a low of 1°, and a mean of 4.5°.

The ten girls (still excluding the un-

usual high) treated in one period had a high decrease of 9°, a low of 1.5°, and a mean of 4.35°.

Discussion

The above mentioned ten boys and ten girls had a starting age range of eleven years six months to fifteen years four months with a mean starting age of thirteen years. The treatment time ranged from fourteen to twenty-two months with a mean of eighteen months.

Klein's sample of twenty-four youngsters was started from seven years seven months to ten years two months with a mean starting age of eight years six months. The treatment time ranged from six to thirty-three months with a mean of seventeen months. These cases were treated with neckband appliances together with flat acrylic bite planes in some cases.

The mean reduction in our twenty full appliance plus neckband cases was 4.42° (if the one zero change case had been included the mean would have become 4.19°). Klein's neckband appliance cases, at an earlier age but with almost the same average treatment time, had a mean convexity decrease of 2.8°.

There would seem to be a significant difference in the convexity change at the two ages. In all probability the addition of the full edgewise appliance did not account for this difference, but rather growth variance in the two age groups was chiefly responsible.

Following the findings of Carlson and King it may well be that a greater increase in face height in the older group was a major contributing factor.

In consideration of the entire group of thirty-four children, less the boy who had no change and the girl who had the unusually high change, the similarity in measurements is noteworthy. The high, low, the mean readings in the two sexes were very close with those of the girls being slightly less in each respect.

Silverstein found that there probably were individual differences in growth trends between the two sexes. He believed, however, that these differences were probably masked by the great variation within each sex.

Most of the workers previously referred to did find that the quantitative change in a great number of measurements in the two sexes showed the same trend, with the boys generally greater than the girls.

NSGn

Previous Findings

From his sample Lande's measurements showed that NSGn evidenced very little change from seven to seventeen years.

Brodie concluded that this angle was quite stable from eight to seventeen. He found no change in it in eleven of nineteen cases. The angle increased around 2° in seven cases and decreased in only one.

Klein measured the Y axis from the Bolton plane and found that in his cervical traction cases it opened an average of 1° with a range from a reduction of 1° to an increase of 3°.

Present Findings

In a total of twenty-two of the thirty-four cases the angle NSGn opened. In the eleven boys showing an increase the high change was 4°, the low .5°, and the mean 1.86°.

In the eleven girls the high was 2.5°, the low .5°, the mean 1.5°.

One boy had a decrease of 1°. Two girls decreased 1° and 2° respectively. Five boys and four girls remained the same.

To recapitulate: in twenty-two cases NSGn increased; in three cases it decreased, and in nine cases it stayed the same.

Discussion

In the face of this evidence, there can be little doubt that treatment with cervical anchorage does tend to cause a bite opening. It is probable also that the addition of a full edgewise appliance and treatment between eleven and fifteen years produced a greater degree of opening.

There is no apparent relationship between length of treatment and degree of NSGn increase. Some of the cases treated the longest showed less than average opening. One boy and one girl in this group stayed the same, and one girl decreased. Those who grow well seem to open the least, again tending to verify the findings of King.

Mandibular Plane

Previous Findings

Lande found a decrease in the inclination of the mandibular lower border associated with the increase in mandibular prognathism. Over half of Brodie's cases demonstrated no notable change in the mandibular border. Where there was a change, it was a decrease.

Silverstein found a decrease in the mandibular plane angle with age. He found also that treatment inhibited this decrease and reversed the normal growth tendency in the female, causing the angle to increase.

King's cases showed an increase in both sexes but this was not as great as that shown by Tovstein in cases treated with Class II elastics.

Present Findings

In six of the boys the mandibular plane angle increased from 1° to 5° with a mean of 2.33°; in eight boys the angle decreased from 1° to 4° with a mean of 2.12°; and in the remaining three the angle was unchanged.

Ten of the girls showed an increase of .5° to 3° with a mean of 1.35°; Five girls showed a decrease of 1° each, and in two girls there was no change.

Therefore, sixteen of the thirty-four cases evidenced an increase in the mandibular plane angle while thirteen had a decrease, and five remained the same.

Discussion

It would appear that about one-half the cases treated with full edgewise appliances plus the neckband appliances tend to show an increase in the mandibular plane angle.

The mean increase in the mandibular plane inclination was greater in the boys than in the girls. Likewise, when the mandibular plane decreased, it did so greater in the boys than in the girls. But the angle in the majority of boys either decreased or remained the same whereas, in the majority of girls it increased. Can the basis for this difference be laid again at the feet of our patron saint, growth?

Can the finding of Lande, that the decrease of the mandibular lower border was associated with the increase in mandibular prognathism, be turned around to apply here? Can it be said that because the girls tend to less mandibular prognathism, that their mandibular planes have less tendency to decrease? And that, therefore, this plane in girls is more easily influenced to increase by treatment?

Palatal Plane

Previous Findings

Brodie noted a definite tendency for the hard palate or nasal floor to remain stable over the entire growth range. In those cases where there was a change, the anterior end dropped more than the posterior. In terms of this paper, the described change was an increase in the palatal plane angle.

In his treatment cases Klein found that the palatal plane predominantly

dropped downward anteriorly; in only four cases did the plane remain the same; in no case was there a decrease of the angle or a greater dropping posteriorly rather than anteriorly.

Present Findings

Twenty-five of the thirty-four cases demonstrated an increase in the palatal plane angle; six showed a decrease; three remained the same.

Twelve boys had an increase of 1° to 5° with a mean of 1.95°. Three of the boys showed a decrease of 1° to 1.5° with a mean of 1.16°. Two boys remained unchanged.

The angle increased in thirteen girls ranging from .5° to 3°. The mean increase was 1.76°. It decreased in three girls 1° each. One girl remained the same.

Discussion

Before discussing the findings, it would be well to point out that delineation of the posterior nasal spine in the headplate of a pre-adolescent youngster can be difficult. This point can be obscured by the shadow of the erupting second molars. It would appear that error is definitely possible, but it may be that this error is duplicated from tracing to tracing thus minimizing its significance.

It seemed, though, that a trend was apparent in treatment cases. The palatal plane angle increased in the majority of Klein's cases and so also did it here. Perhaps, as Klein speculated, cervical traction can alter the basic maxillary structure.

The small decrease in the angle in six cases is not understandable on the basis of previous findings and may be due to error in tracing.

Summary

In Class II, Division 1 and Class II tendency cases treated with full edgewise appliances plus neckband appliances as auxiliaries the following observations were made:

1. The angles SNA and NAPo were generally reduced.
2. The SA distance was reduced in the majority of cases. This reduction occurred more often in the female than in the male. In the boys A moved forward as often as backward. The millimeter change in forward movement was greater than that which occurred in backward movement.
3. SNB behaved similarly in both sexes. It tended to stay the same or decrease, as often as it increased. The decreases when registered were smaller than the increases and may have been influenced by bite opening.
4. The SNPo measurements were strikingly like those of SNB. The only real difference was that the degree of increase of SNPo was slightly greater than that of SNB.
5. The SB distance increased in the majority of both boys and girls. The increase in the boys was greater than that in the girls, numerically and quantitatively.
6. The differences between angular and linear measurements of points A and B respectively indicate a masking of true events in the recordings of angles. It should be remembered that SNA, SNB, and NAPo are influenced by growth activity at points other than A and B.
7. NSGn increased in the majority of cases, indicating the bite-opening propensities of the appliances.
8. The mandibular plane either decreased or stayed the same in most of the boys whereas it tended to increase in the majority of girls. This may be another indication of greater growth forces in the male than in the female.
9. The palatal plane increased in the majority of both boys and girls. If the possibility of error in tracing could be discounted, this increase would be indicative of a tendency for the neckband

appliance to change the palatal plane in a natural direction.

The recognized variables in a study of this type primarily concern the patient. Not only are there differences between the sexes, but also, there are wide individual variations: of growth activity related to age, of tissue responses to orthodontic pressures, and of individual patient cooperation in following instructions. The fact that the majority of patients respond in one way in one area of measurement does not prognosticate like reaction in any other individual.

This paper is presented with full recognition of the above facts, as a record of changes in some patients to one form of clinical management.

Medical Art Square

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Appraisal Of Speech Defects In Dental Anomalies With Reference To Speech Improvement*

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In the summer of 1952, Rathbone[5] initiated a study to ascertain the relative effectiveness of the orthodontist in appraising the speech defects of his patients prior to orthodontic treatment. Dr. John Snidecor, Professor of Speech at the University of California, Santa Barbara College, cooperated in devising, testing, and recording techniques and served as criterion judge for this experiment. As this study took form, it was expanded to include the prediction of speech defects from models alone, the relation of the severity of the malocclusion to the severity of the speech defect, and the reappraisal of the speech defect following all orthodontic treatment with no speech correction. It is, therefore, the purpose of this paper to review the results of the original study and to present the results of the reappraisal of the speech defect following all orthodontic treatment with reference to speech improvement. This is a report of a clinical study which was done with a limited population and with the resources that were readily available.

In the original study ten cases were picked which before orthodontic treatment had various types of malocclusions and definite speech defects. The sample is small, but both authors feel that these ten cases are indicative of what one can expect.

*Read before the Angle Society of Orthodontia, Washington, D. C., October, 1957.

Our method of testing was by using test sentences devised by Snidecor. The procedure followed was to have the orthodontist rate the severity of the malocclusion, the models were then examined by the speech therapist to determine what dental sounds he would predict as defective and the degree of predicted deviation. Each patient was then asked to read the test sentences and all defects were noted and graded by each examiner. All procedures of testing were done independently by each examiner. The above testing was done prior to orthodontic treatment.

Of the ten subjects in the original study, four presented very marked malocclusions, four had marked malocclusions and two had slight malocclusions. All subjects presented normal hearing and intelligence. Orthodontic correction was oriented toward effective structures for speech as well as toward the more traditional goals of the orthodontist. Pound[4] and others have pointed out clearly the need for such considerations.

The test sentences used in the original study and in the reappraisal are stated directly below:

Test Sentences

1. Post-dental (tongue back of the anterior teeth) *n, t, d, r, l, s, sh, z, zh, y.*

   n - Her name was Ann and she lived near Dan.

t - Terry counted the kittens and took three for his sister.

d - Donald did not have the doll or the dog, but he did have an old radio.

r - Roy watched the rabbit run around the chair.

l - The lad lit the lamp and did his school work.

s - The six sisters in red dresses sang school songs.

sh - She washed the dishes and put them on the shelf at the shop.

z - The boys were surprised at the zebra in the zoo.

zh - Their father hid the television set in the garage.

y - The young girl was amused by the three yards of yellow yarn which she found in the yard.

2. Lingua-Dental (tongue and teeth sounds) *th* (unvoiced) *th* (voiced).

   th (unvoiced) - The thin thief stole the three thimbles, but could find nothing else.

   th (voiced) - That lathe belongs to my father and brother.

3. Labio-dental (lip and teeth sounds) *f, v*.

   f - His father found the loaf of bread and coffee on the sofa.

   v - He has seven vests, one for every suit.

4. Post-dental Combinations (tongue back of anterior teeth, each sound is a combination of two sounds) *ch, j*.

   ch - The teacher told the children to chew the cherries carefully.

   j - Jack ate the jam and drank his orange juice.

Stated very briefly the major conclusions from the first study were as follows:

1. The nature and history of the problem were presented.
2. The use of simple test sentences as a means of diagnosing speech defects proved to be a reliable guide for the orthodontist. This assumption is based on the percentage agreement, 91.4%, reached by the orthodontist with the speech therapist in regard to the more common dental fricative sounds, *s, sh, z* and *zh*. When all dental sounds were considered our percentage agreement was only 51.3%, a figure which could be expected as a result of the lack of speech training on the part of the orthodontist.
3. There is no one-to-one relationship between the severity of the malocclusion and the severity of the speech defect. This is in keeping with the findings of Kessler[3] who has pointed out that many individuals with malocclusions have satisfactory speech by virtue of their ability to compensate in producing sounds. The previous works of Bruggeman[1] and Fymbo[2] support this view. For the same reason models alone in judging defective sounds were found to be insufficient in accuracy for the prediction of faulty dental sounds.

Four Year Re-evaluation, with Reference to Speech Improvement

After a period of four years, eight of the ten original subjects were available and re-examined with the same speech test stated above. In view of the fact that the speech correctionist was a more critical judge than the orthodontist, only his test results were utilized. It was also thought that the continuous contact with the subjects might cause an unintentional and unpredictable bias on the part of the orthodontist.

Conditions established for the re-evaluation were as follows:

1. At the time of the first test and the beginning of orthodontic treatment public school speech therapists and parents were re-

quested not to institute speech therapy until dental correction was completed.

2. The speech re-test was completed without reference to the results of the test administered four years before.
3. Prior to re-test all orthodontic treatment had been completed, both active and retentive.

Upon original examination all of the subjects presented highly noticeable defective speech. Of the sixteen dental sounds tested a mean of 6.4 sounds were found defective for all ten subjects, and a mean of 6.4 for the eight subjects here reported. One subject presented only three faulty sounds in the original test, whereas another subject had twelve faulty sounds.

When all subjects are considered, one finds that all dental sounds were faulty, but that errors tended to concentrate on the dental fricatives, *s*, *z*, *sh*, *zh*, and *th*.

In the second test the same concentration of errors in a milder degree occurred in these fricatives with fewer errors in the other dental sounds. Careful study of the final casts indicated few, if any, residual organic and structural reasons for residual defective sounds. If the speech therapist had judged faulty sounds from the casts alone, as he did in the first study, few, if any, sounds would have been predicted as faulty.

Despite residual errors in all cases the spontaneous improvement in speech articulation following orthodontic correction was dramatic. Without speech correction faulty sounds dropped from a mean of 6.4 to a mean of 1.5. In other words, for eight cases and from sixteen sounds tested a mean of 6.4 sounds was found defective before orthodontic treatment, and a mean of 1.5 sounds was found faulty four years later when re-tested using the same test sentences. The residual speech errors noted on re-testing were observed only in the highly noticeable fricative sounds.

Because all of the subjects presented normal intelligence, normal hearing, and now present excellent to good occlusion, it can readily be predicted that speech therapy should be highly productive at this time and would probably eliminate all noticeable errors in the articulation of the remaining faulty fricative dental sounds.

The following case, which is demonstrated in Figure 1 left, was selected as an example because of the severity of the malocclusion and the various dental conditions present which could contribute to defective speech.

This subject was a female eighteen years of age who had a very marked Class I malocclusion. This case presented the following dental conditions pertaining to speech: 1) high palate, 2) narrow maxillary width due to crossbite on the right side, 3) severe maxillary anterior rotations, 4) maxillary anterior spaces, 5) thick maxillary anterior alveolar ridge, and 6) a mild maxillary protrusion. About the only dental condition missing was an openbite and in this case the bite is slightly closed.

The treatment of this case involved the extraction of the four permanent first bicuspids and the placement of edgewise bands on all mandibular and maxillary teeth including second molars. Active treatment with a series of archwires and the employment of elastics took a period of approximately twenty-two months. At this time all bands were removed and a removable maxillary Hawley plate with a fixed mandibular cuspid to cuspid retainer were placed. The retention period covered eighteen months during which the maxillary retainer was worn continuously for twelve months and at night only for the last six months. This subject was continued under observation following retention and the case has maintained itself in

excellent condition, as shown in Figure 1 right. Considering the age of this patient, the results achieved were most gratifying.

Summary

Based on a study of subjects prior to

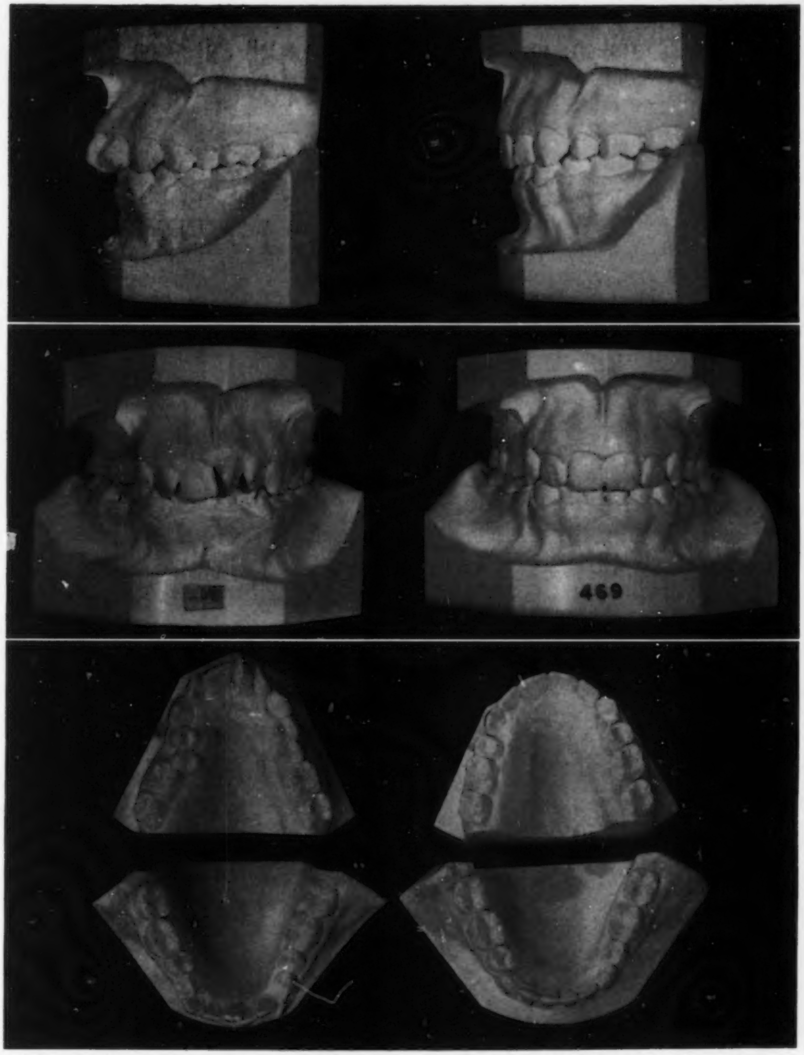

Fig. 1 **Left, before treatment with defective sounds *t, d, r, s, l, sh, z, zh, th, ch*, and *j*. Right, following treatment with residual defective sounds *s, z*, and *th*. The high palate is still present and a mild overbite; these two factors could cause residual speech errors in that the combination of the two could affect correct tongue placement for maximum results. Slight maxillary anterior spaces not shown in the photographs are contributing factors.**

orthodontic treatment and a re-study of them four years later following all orthodontic correction, the conclusions stated below appear tenable:

1. Orthodontic treatment without speech correction reduced the number of faulty dental sounds from a mean of 6.4 to a mean of 1.5. Subjects were intelligent and had normal hearing.
2. Despite orthodontic treatment, residual speech errors were observed in the highly noticeable fricatives *s, z, sh, zh,* and *th,* but to a lesser degree both qualitatively and quantitatively. Other dental sounds had improved to the point where errors were not detectable.
3. A careful study of the final casts indicate few, if any, reasons for these errors and point to the need for speech therapy with an optimistic view for perfect or near perfect speech.
4. Generally speaking, this study supports the view that improved structural factors predict improvements in speech with residual errors that can be reduced or eliminated through speech therapy.

Practical Application of Speech in an Orthodontic Office

Using this study in conjunction with the work of Bruggeman[1] and others, we believe there are definite applications of speech testing and recommend that these can be followed in the orthodontist's office. These recommendations concern three factors which should be discussed with the parents:

1. Testing and evaluation of defective sounds by use of test sentences previously outlined.
2. General development of speech sounds, especially the dental sounds.
3. Dental anomalies associated with speech defects, and predicted improvement resulting, in part, from orthodontic correction.

In considering the testing and evaluation of defective sounds, it must be simple and require little time, as speech is only a small part of an orthodontic diagnosis. Such testing by the orthodontist has been shown to be valid and can be done by simple test sentences or words selected from such sentences when reading skill is limited. By actual testing, the orthodontist is in a position to confirm whether the patient has a speech defect or not.

The next step is to explain the general development of speech. This can be stated simply that speech sounds, except the very simple vowels, develop in a normal child gradually and progressively until the seventh year and that most, if not all, of the sounds will be articulated correctly. Speech is a learned process, and a child will assume the speech standards that exist in his environment. One simple way of grading the difficulty of speech sounds was shown by Wellman[6], Case, Mengert and Bradbury, in which they considered the age at which the sounds in question are made correctly by 75% of the children tested. The following is their reference table for dental sounds adapted from *Speech Sounds of Young Children*:

1. 75% at 2 years of age - *n, t, d.*
2. 75% at 3 years of age - *f, z.*
3. 75% at 4 years of age - *v, r, l, y* (you), *ch, j,* (judge).
4. 75% at 5 years of age - *th* (voiced), *th* (unvoiced), *s, sh, zh* (measure).

Perfection in their production for most children need not be expected until about their seventh birthday. The parents should now have an idea on how speech sounds develop and why their child of six to eight years with spaces or unerupted laterals should hiss when making an s sound. Group four sounds are all friction sounds and de-

pend to a marked degree on effective structure and function of the articulatory mechanism.

The next step which should be discussed is that of the dental anomalies which are associated with speech defects. For this purpose, the graduate thesis of Bruggeman[1] was used, utilizing only the results of the female group, because females are able to produce better speech where the abnormal occlusion is the same.

The following dental anomalies are associated with speech. The sounds expected to be found faulty are listed with each dental anomaly.

Spaces — all dental sounds except *n* and *y* especially *s, sh, z, zh* are friction sounds.

High palate — dental sounds *s, z, th, r* and *l.*

Width of arch — dental sounds *s, z, th.*

Open bite — dental sounds *s, sh, z, zh, th,* and, occasionally, *t* and *d.*

Degree of Protrusion — dental sounds *s, sh, z, zh*
other friction sounds and, occasionally, other dental sounds.

Thickness of alveolar ridge in upper anterior region — dental sounds *s, sh, z,* the friction sounds.

Severity of rotated teeth — same as spaces.

The orthodontist is now in a position to point out what dental conditions exist in the malocclusion that *could* contribute to the child's speech defect. As previously shown, a child or person has the ability to compensate for defective structure in the production of sound, and for this reason one cannot predict that a definite dental condition will cause a definite speech defect. Such dental conditions can only be a guide in the consideration of any speech defect.

After consideration of all these factors, and where the malocclusion is severe and can be a factor in defective speech, it is frequently our recommendation that speech therapy should be delayed until orthodontic treatment is completed or well under way. Likewise, defective speech can be a factor as to the time to institute orthodontic treatment in order that the child may have a better oral mechanism with which to articulate the dental sounds.

The recognition of speech defects is another service that orthodontists can render their patients in considering any malocclusion. Such recognition could be the deciding factor in the determination of when to start treatment. Improvement in speech can be predicted with improved structural factors and any residual errors can be reduced or eliminated by the process of learning.

Therefore, the orthodontist's responsibility to speech disorders is, first, to be able to recognize defective sounds and to recognize the importance the dental structure has in relation to the production and articulation of speech sounds. Second, it is his responsibility to place the oral structure in the most normal possible relationship so that rehabilitation of speech can be accomplished.

1808 State St.

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Case Report

HERBERT PASKOW, D.D.S.
Elizabeth, N. J.

DIAGNOSIS

This malocclusion is classified as Class II, Division 2 with a missing upper right central incisor. All remaining teeth are permanent and present with the exception of third molars. Space closure is obvious with mesial migration of all teeth anterior of the maxillary first premolars. The left central incisor appears directly in the midline of the face. Occlusion of the posterior teeth appears edge-to-edge tending toward Class II interdigitation.

HISTORY

The patient was first seen at age eights years and six months. She favored the right side in masticating and a possible lip-biting habit was present. Questioning revealed the following: a fall at age three was responsible for the loss of the maxillary right deciduous central incisor; the maxillary right permanent central incisor which erupted at seven apparently was defective, and it too was lost due to trauma soon after. The case originally presented itself as a Class II, Division 1 with mutilation as above; however, as the years ensued, the procumbent anteriors apparently were linguoverted by normal lip pressure. The patient was observed every six months or so until July, 1955, at which time a complete case analysis was made.

ETIOLOGY

The hereditary aspect of this case must be considered of etiologic significance, ordinarily producing a Class II, Division 1 malocclusion. However, the loss of the permanent right maxillary central incisor has produced a mutilated Class II, Division 2 malocclusion.

TREATMENT PLAN

In view of this mutilated condition, removal of the maxillary left central incisor is indicated, followed by alignment of the roots of the lateral incisors while moving them into closer approximation. Adjustment of buccal interdigitation into a completely Class II relationship is needed. When alignment is completed, the maxillary canines can be shaped to resemble laterals, and the true laterals jacket-crowned to resemble maxillary central incisors. The lingual cusps of the maxillary first premolars can be reduced, to resemble canines.

APPLIANCES

Following the removal of the maxillary left central incisor, edgewise bands were placed on the maxillary lateral incisors, canines, first premolars and first molars. By gentle pressure of intramaxillary elastics from the left to right lateral, these teeth were moved mesially. This was followed by mesial migration and improved interdigitation of the posterior segments; meanwhile round archwires were placed beginning with an .014 and ending with an .021 by .025 with vertical loops and tie-backs incorporated.

A retaining appliance of the removable Hawley type was to be placed immediately following therapy. Jacket-crowns were to be prepared and cemented soon after, and the case's occlusion equilibrated.

PROGRESS

The patient was seen from two to

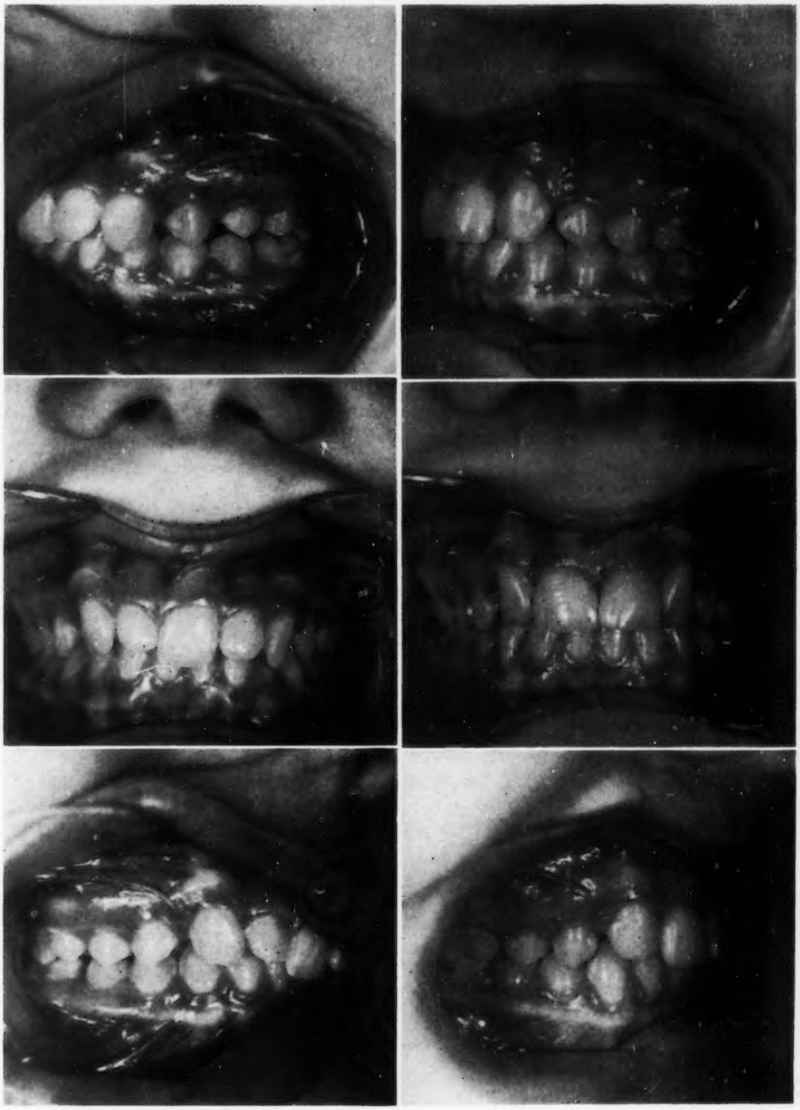

Fig. 1 Left, intraoral photographs taken prior to treatment. Note missing maxillary right central incisor and Class II tendency of posteriors. Right, intraoral photographs made one year out of retention with jacket crowns on laterals to resemble centrals and equilibrated canines resembling lateral incisors.

four week intervals following band placement. Cooperation in wearing the intramaxillary elastics was good. Hygiene was excellent. Bands were first cemented in August, 1955; the edgewise archwire inserted in January, 1956. Bands were removed in September, 1956 and the occlusion retained.

The retainer was worn while the family dentist prepared the jacket crowns, but was discarded immediately following crown cementation. In December, 1956, the occlusion was equilibrated and final records taken.

Conclusions

Correction of facial and intraoral cosmetics is noted, a midline has been restored and central incisors have been "replaced". Functional improvement is noted in the posterior segments by excellent interdigitation, but of a Class II relationship.

Active treatment was of but one year duration. An attempt at treating this case without any extractions (as a Class II, Div. 1 or 2 case with head cap or intermaxillary elastics) undoubtedly would have taken much longer and would have required a removable and later a fixed restoration. Extraction of maxillary (and mandibular) premolars was also considered, but treatment would have been more complex. X-rays taken following treatment revealed improved root parallelism of lateral incisors and little, if any, root resorption.

Acknowledgement for the cooperation and treatment planning as well as the excellent restorative dentistry must be given Dr. W. W. Jordan of Cranford, N.J.

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